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Report of the

North Central Conference on Biology Teaching

conducted by

The National Association of Biology Teachers

August 19-30, 1955 Cheboygan, Michigan

## THE AMERICAN BIOLOGY TEACHER

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## Cover Photograph

This view captures some of the beauty of The University of Michigan Biological Station at Douglas Lake, Michigan. Photograph, courtesy of Alfred Stockard, Director of the Station.

# THE NATIONAL ASSOCIATION OF BIOLOGY TEACHERS

Report of the

# NORTH CENTRAL CONFERENCE ON BIOLOGY TEACHING

held at the

University of Michigan
Biological Station
Cheboygan, Michigan

**AUGUST 19-30, 1955**

*Conducted by*

THE NATIONAL ASSOCIATION OF BIOLOGY TEACHERS

in cooperation with

The American Institute of Biological Sciences

*Supported by a grant from*

The National Science Foundation

THE STAFF
Richard Armacost, Paul Klinge, John Breukelman, Alfred Stockard, and the Director, Richard L. Weaver.

# PREFACE

Ever since its organization in 1938, The National Association of Biology Teachers has kept as its foremost aim the improvement of biology teaching at all levels, particularly at the high school level. The membership of the organization consists of elementary, high school, and college biology teachers, as well as many others interested in the improvement of teaching. One of the first acts of the organizational meeting in 1938 was the establishment of an official journal, *The American Biology Teacher.* Ever since the first issue October 1938, this journal has been published through the school year, from October to May. Through its journal and through standing and special committees, NABT has contributed much, not only to teaching techniques and materials, but also to a better understanding among teachers at the various levels.

One outstanding special committee of the National Association of Biology Teachers was that on conservation education, which under the direction of Richard L. Weaver has completed a three-year nation-wide study of conservation teaching in the public schools, and recently has published a handbook on teaching conservation and resource-use.[1] This activity was made possible by a $10,000 grant from the American Nature Association.

In the spring of 1954, the National Science Foundation announced a grant of $15,000 to finance a ten-day work conference, to be held at the University of Florida preceding the annual meeting of the American Institute of Biological Sciences, of which NABT is a member. The report of this conference, under the joint direction of Richard L. Weaver and Samuel L. Meyer of Florida State University, was printed as the January, 1955, issue of *The American Biology Teacher.*

Last year the National Science Foundation awarded NABT a second $15,000 grant to finance a conference to be held in Michigan preceding the 1955 meeting of AIBS in East Lansing. The planning committee for this conference, which met in Chicago in February, 1955, chose as the site of this meeting the University of Michigan Biological Station, Douglas Lake, Michigan. The committee decided to base the deliberations on the following five areas of applied biology: health and disease, human genetics, the food supply of

[1] *Handbook for Teaching of Conservation and Resource-Use,* The Interstate Printers and Publishers, Inc., Danville, Illinois, 1955, $4.00.

man, plants and man, conservation. It was agreed that this emphasis on applied biology would encourage further exploration of the areas of basic biology studied in the Florida conference in 1954.

The planning committee chose Richard L. Weaver as director and John Breukelman as chairman of the steering committee. Other staff members were Richard Armacost and Paul Klinge, Co-editors of *The American Biology Teacher*, and Alfred H. Stockard, Director of the Michigan Biological Station. Much credit for the success of the conference goes to Dr. Stockard. The excellent facilities of the station, with all participants living on the campus and eating at the station cafeteria contributed greatly to effective group work.

In addition to the staff, other members of the steering committee were as follows: Brother H. Charles, F.S.C., President NABT; Arthur Baker, Past President NABT; Muriel Beuschlein, Secretary, Steering Committee; George W. Jeffers, Longwood College, Farmville, Virginia; Irving C. Keene, Brookline High School, Brookline, Massachusetts; Howard M. Phillips, Dean, Graduate School, Emory University, Georgia; Harvey Stork, Carleton College, Northfield, Minnesota; and Paul V. Webster, Secretary-Treasurer NABT.

The editorial committee responsible for the 1955 report consisted of ABT Co-editors Richard Armacost and Paul Klinge, Richard L. Weaver, and John Breukelman. Photographs for the report were taken by Richard L. Weaver.

Copies of the report can be secured from Paul Webster, Secretary-Treasurer NABT, Bryan City Schools, Bryan, Ohio.

John Breukelman
Chairman, Steering Committee

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# Introduction

*Objectives of the Conference*

Four objectives, very similar to those selected for the Southeastern Conference, were agreed upon for the North Central Conference. They were:

1. To study the contributions of biology to living, and to develop a set of basic principles and practical experiences which are essential for biology teachers and pupils.

   The areas selected were:

   conservation of natural resources; food supply of man; plants and man; human inheritance; and health and disease.

2. To analyze and select some of the most important problems of biology teaching at various levels of instruction and in State Departments of Public Instruction.
3. To develop a set of recommendations for the solution of the selected problems.
4. To formulate plans by state teams for implementing the recommendations.

It was recognized at the conference that not all readers of the North Central Conference Report would have access to copies of the report on the Southeastern Conference, so some material from the first conference would have to be included in this report, particularly in the section on "Recommendations."

*Selection of Participants*

Teams of participants were selected from the ten North Central States by the Director and staff members from lists of people nominated by members of the Steering Committee, and by representatives of the State Departments of Public Instruction, state and national professional organizations such as the American Institute of Biological Sciences, the National Science Teachers Association, the American Nature Study Society, the Central Association of Science and Mathematics Teachers, the American Association for the Advancement of Science, and the National Research Council.

Each team was composed of two or more high school teachers or teachers in training, two to four college teachers of biology and/or science education, and professional educators and/or public school administrators. In cases where it was not possible to fill state quotas or distribution patterns, substitutions were made from other states and other catego-

ries. Six or seven persons who expressed a specific interest in attending the conference were also included.

Leaders were chosen largely from the officers of the National Association of Biology Teachers or other organizations cooperating with them.

*Organization and Execution of Conference Plans*

PART I

Each of the five scientists who served as consultants was asked to prepare a working paper in the area he represented, to include the following:

1. The essential subject matter necessary for the preparation of the high school teacher.
2. Recent scientific developments of significance to that area, and
3. The experiences and methods by which such content might be transmitted to students.

The 90 participants were placed in five groups with as great a distribution geographically and professionally as possible.

. The consultant and his recorder met with each group for two hours to discuss the content of the paper and for two more hours to discuss ways of teaching the material to teachers or to high school students.

The recorders were charged with the responsibilty of recording the teaching suggestions of the groups, while the consultants incorporated any new ideas of the groups on content in revised versions of their papers. These revisions are presented in this report. Thus each topic received twenty hours of consideration at the conference since each consultant repeated his presentation five times. Richard Armacost, one of the five staff members, arranged for the selection and orientation of the consultants and coordinated this part of the conference.

PART II

A. *Selection of Problems*

Prior to the conference the Director prepared a summary of the problems covered in the Southeastern Conference. Included were problems considered important, but for which there were no recommendations because of lack of time.

The summaries were sent to all the participants prior to the conference, with instructions to indicate priority of interest and to add new problems.

Paul Klinge, another staff member, compiled the suggestions on problems and prepared an organizational pattern for use by the participants. The staff, group leaders, and recorders for Part II of the conference assisted Klinge in organizing the problems for consideration.

The participants were rearranged into four groups for consideration of the problems in Part II of the conference. Chairmen and recorders were selected.

One session of two hours was used by the four groups to consider the problems as organized and presented by the staff on the basis of pre-conference questionnaires. The groups indicated their suggested changes and priorities. The four groups then assembled together at a second session to select the final problems for discussion. Many large problems were broken down into smaller problems to be studied.

These groups then met in two-hour sessions seven times, plus numerous small group sessions to prepare special parts of the recommendations on problems of their specific interest.

B. *Preparing Recommendations*

The four groups considered all of the 17 problems selected and made recommendations on each. The four groups used four different methods of procedure in arriving at their group recommendations.

One group explored each problem by discussion and summarized tentative recommendations on a blackboard. They then subdivided into small groups to edit a written report which was brought back to the group for approval. An observer assisted this group.

Another group also discussed all the problems serially as listed. Occasionally one or two participants would volunteer to work between sessions to word a statement that would represent the opinion of the group. Near the mid-point of the seven working sessions, related questions were grouped into five sec-

NABT OFFICERS

*First Row:* President Brother Charles; First Vice-President Edna Higbee; Second Vice-President Enid Larsen. Third Vice-President Robert Smith; Past President Arthur Baker.

*Second Row:* Co-Editor, Richard Armacost; Managing Editor, Muriel Beuschlein; Co-Editor Paul Klinge and Secretary Treasurer, Paul Webster.

tions. This group then formed five committees of three participants each, each committee to be responsible for summarizing one section of the problems. One or more members of each committee then kept notes on the discussion. Each sub-committee then wrote a report on its section. The last session was devoted to hearing each committee's report and amending it as seemed necessary.

A third committee took up the problems sequentially and formulated their recommendations as a group with the use of the blackboard. The chairman and recorder processed the material between sessions and reported the edited results to the group for approval and changes as needed.

The fourth group discussed the questions long enough to ascertain the interest of individuals in the various problems. Then they elected to work in small groups to prepare recommendations on specific items which were later presented and edited by the entire group.

### C. *Melding Recommendations*

Three sessions of two and a half hours each were used to present the group reports and to decide on which parts to use in the final report or what changes to make. The chairmen, recorders, and staff coordinator, Paul Klinge, rewrote the group reports into one report, incorporating the changes agreed upon by all the participants. This was done during state team meetings.

The final report was retyped and distributed to all participants for consideration at the final session of the conference, where final agreement was reached after certain changes were suggested and approved.

### *State Team Plans*

Each state team met in a two-hour session to decide on how to implement the conference recommendations.

Robert Koopman of the Michigan Department of Public Instruction and Richard Armacost assisted the state teams in the preparation of their reports. Chairmen selected by the teams met with the two staff members at dinner to share their findings, and to prepare plans for presentation of a report to all participants in a general session.

While the individual state plans are not included in this Report, Dr. Koopman's Sum-

mary includes all of the suggestions in them, and serves as a blue-print of action for all participants. If you live in any of the ten states included in the conference and want to help in your own state program of Improvement of Biology Teaching feel free to contact members of the state team to volunteer your services.

### *Conference Evaluation*

Both parts of the conference were evaluated by a variety of techniques including checksheets and small group interviews. An evaluation committee consisting of two general consultants and a representative from each group was set up at the beginning of Part II.

The evaluation responses were highly approving of the general worth-whileness of the conference experience, of the selection of participants from both high school and college groups, and of the choice of a field station as a site for the conference. There was some feeling that there should have been greater representation of elementary science teachers and of state department leadership.

The constructive suggestions dealt mainly with how to create a conference structure, that would facilitate to the greatest extent, the efforts of the participants to achieve the purposes of The Conference. The use of the consultants was highly valued, but it was felt that the lecture technique did not result in full use of their services. Another problem was how to utilize the thinking of previous conferences without depriving present participants of the experiences of thinking through central issues in biology teaching.

The participants focused upon future conferences with a wide range of suggestions. One common pattern ran through most of the suggestions; namely, a deep concern for the nature of the high school course in biology and, logically, for the introductory college biology course. That concern centered around (1) objectives, (2) content, (3) techniques. "We need a conference to tackle basic biological training" said one participant; another claimed "we need to resolve our philosophy about biology;" still another wrote of "a need to understand general education."

These suggestions are spelled out in the original report of the Evaluation Committee. Anyone interested in the complete report of the committee can obtain a copy from the Director of the Conference.

The Evaluation Committee recommended that the planning of any future conferences include the appointment of an evaluation committee at the conference planning stage and that evaluation techniques be planned as the conference structure evolved.

Dr. Dorothy McCuskey of Bowling Green State University in Ohio served as chairman of the Evaluation Team. The Team prepared an evaluation form for the conference and summarized the suggestions of the participants at the final session.

### *Field Trips, Clinics, and Exhibits*

Dr. Alfred Stockard conducted boat tours around Douglas Lake for all participants, while Dr. Charles W. Creaser of the Biological Station Staff led a land trip. Thus all members of The Conference had an opportunity to study the ecology of the area and see the richness of the flora and fauna.

Dean Samuel T. Dana was asked by one of his groups to lead them on a special forestry trip. Dr. John C. Ayers, Great Lakes Research Institute Staff and Investigator at the Biological Station, was asked to work with a selected group under the leadership of Mrs. Catherine Dale of Indianapolis on limnology projects suitable for science fairs.

A series of field trips to bogs and other interesting areas in the vicinity was led by Miss Elsie Townsend of Wayne University and Miss Anges Kugel of Grand Rapids Junior College. A collection of local plants was assembled, arranged, and labeled by Miss Kugel and Miss Virginia Esten.

### *Biological Station Facilities*

The Biological Station offered unique resources for the execution of such a work conference, with excellent meeting rooms, adequate housing, excellent meals, unusual swimming, fishing, and other recreational resources available, and a most competent and efficient staff.

Richard L. Weaver
Director

# PART I: Some Contributions of Certain Areas of Biology to the Training of Biology Teachers

## Plants and Man

JOHN S. KARLING
Head, Department of Biological Sciences
Purdue University

In any attempt to teach the relation of plants to man and the impact of plants on man's past and daily life, the biology teacher should have a clear concept of man's position in the community of living things and his relation to environment. As a background of general knowledge the teacher should recognize for proper perspective that:

A. Man and all other animals are in reality guests of plants on this earth, and without green plants as a direct or indirect source of food, animal life would soon cease. Of all living organisms on this planet, green plants alone are able to deal directly with the world's only great source of energy—the sun. They have a monopoly of the business of trapping, converting and storing the sun's energy as food and other products without which man or animals cannot survive. Despite all efforts so far, man has been unable to break this monopoly. Accordingly, photosynthesis is the most basic of all plant-animal relationships, and forms the background for the panorama of life's existence. The chloroplasts have been described as the chief agency which stands between man's eventual starvation and extinction.

Although civilized man is a guest of plants he is the arch predator and the pre-eminent deranging and destructive force in Nature. He has always been a disturbing biological force because of his depredations, but within the past century he has also become a major geological force. His construction of huge dams, super-highways, use of atomic power for destruction, removal of forests, overgrazing and faulty land use, which led to erosion by wind and water, is rapidly changing the land surface of the earth.

B. Besides providing man with food for daily survival, plants impinge closely on his life in another equally essential manner. Bacteria and fungi break down the complex molecules and return the by-products to the inorganic realm where they may be used again in making food. Without bacteria and fungi there would be no decay or decomposition, and were there no decay, the surface of the earth would become covered with the carcasses and remains of countless generations of animals and plants. The mechanical obstruction of undecomposed plant and animal remains would make life impossible. Also, vital elements would become locked up in this debris, unavailable to future generations of plants for metabolism into essential plant and animal tissues. Atoms might, thus, be used but once, and soils would eventually become depleted of all essential elements.

C. At the same time bacteria and fungi are the principal etiologic agents of disease in man and other animals. Although man regards them as his useful servant, as noted above, and is dependent on them throughout his entire life, they may also be a destructive master.

D. Plants are still the principal sources of medicinals for the alleviation and cure of the diseases which the above agents cause in man.

E. Plants have played a significant role in man's evolution and cultural development. The origin and evolution of angiosperms and the seed bearing habit with its concomitant concentration of proteins, carbohydrates and fats in seeds accentuated the development and

ascendency of the better-adapted mammal and marked the end of massive animals with huge jaws and digestive tracts. Fossil records show that the development of mammals and angiosperms went hand in hand through the Mesozoic and Cenozoic eras, and eventually culminated in the dominant mammal-man who was dependent from the start for his existence directly or indirectly on seed plants.

Prehistoric man existed by gathering angiosperm seeds, fruits and succulent herbage, or by killing game which in turn had fed on angiosperms. Without angiosperms and their seeds, he would have had no flour or gruel for food; without fibrous barks, no fibers or material for cordage or basketry. Without secondary growth in angiosperms and the development of woody stems his shelter would have been inadequate; without grasses he could not have kept and developed herds for meat and other food products. And even more significant, without the evolution of herbaceous seed-bearing annuals man could not have established agriculture. The establishment of agriculture or the domestication of plants and animals between eight and ten thousand years ago was of greater significance to the future of the human race than anything that has happened since that time. This provided a dependable food supply and with it came a gradual change from the nomadic, roving, and hunting to a more sedentary mode of life and the gradual development of permanent settlements. A dependable food supply gave man time and energy for cultural development, and with agriculture once established advances in social, civil, political and ecclesiastical organization became possible. Present evidence indicates that man's early civilizations sprang up at the sites of origin and domestication of certain crop plants and animals. The beginnings of the Mayan and Incan civilizations began, for example, in the highlands of southern Mexico, Central and South America and were based principally on the origin and domestication of corn, beans, potatoes and a few animals. The Mediterranean civilizations began at the sites of origin of most cereal grains, truck crops or vegetables, principal present-day fruits and domesticated animals in the Mediterranean region. Similarly, the ancient civilizations of China, Indo-Malayo, Central Asia and the Near East originated at the centers where millet, buckwheat, rice, soybeans, legumes, coix, yams, citrus fruits, spices, and numerous other crop plants had their origin and were domesticated.

In light of the influence of plants on man's daily life as well as his past development, a study of botany is obviously as essential as zoology in the training of a biology teacher, but his training should be such that he will be able to see the biological world as a whole and to integrate the plant and animal sciences. Biology is an inclusive science and not strictly botany or zoology *per se*. The physical basis of life and structure as well as the fundamental principles of metabolism, respiration, growth, reproduction, response to stimuli, inheritance and evolution are the same in all living things and not the property of any group—animal or plant. Therefore, botany should be closely integrated with zoology in a general biology course to present an interrelated picture of the living world. It is an all too common mistake, particularly in college courses, to devote one semester exclusively to zoology and another one to botany, or vice versa, as if they were almost distinct sciences. This usually presents a disjointed view, and does not give the student a broad perspective of the living community of which he is a part. To serve the largest number of students general biology courses must have balance, not only between botany and zoology but between the subject matter in each science. Morphology and taxonomy, for instance, should not be over-emphasized to the neglect of other subjects, and only by maintaining a proper balance can the teacher expect to develop broad-minded, educated and well-balanced biology students. Obviously, much attention cannot be given to any single subject, and emphasis should be placed on broad basic principles. Nevertheless, understanding and appreciation of basic principles require a considerable amount of subject-matter knowledge and should not be neglected.

From the viewpoint of man's and other animals' complete dependence on plants and the fact that functional life is manifested largely by the transformation and use of energy, the part played by plants in the energy relations of living matter should be among the

first strictly botanical subjects in the training of the biology teacher. It should be clearly understood that the energy of the sun is made available to animals principally by the green plant. This involves knowledge of the green plant's structural adaptations as an energy trap and food builder as well as its leaf and cell structure, chloroplasts and chlorophyll, and also of the process of photosynthesis. Then, to get a complete picture of the energy relations, the biology teacher should know the part played by plants (bacteria and fungi) in decay or decomposition of animal and plant remains and organic wastes; the breakdown of these into simpler and more oxidized elements and their liberation so that they may be utilized again. This involves principally the carbon and nitrogen cycles.

That the biology teacher should know about the characteristics of living matter, life's residence in protoplasm, the similarity in structure and composition of plant and animal protoplasm, its organization into cells, their similarity in structure, and their function in the multicellular organisms as the unit of structure, growth, differentiation, reproduction and physiological activity goes without saying. This implies knowledge of readily available sources of living plant protoplasm, and the variety of cell sizes and shapes in plants for class use in conjunction with animal material and some training in general plant cytology.

After the energy relations, characteristics of living matter, universality of protoplasm in living things, and its structure and organization have been presented, broad and balanced courses in biology usually proceed to the demonstration of the variety of form in plants and animals. To do this effectively, the teacher must have a broad training in many other aspects of biology including taxonomy, systematics, comparative morphology, and anatomy. As an introduction to a brief survey of plants and animals the teacher must be familiar with nomenclature, classification, and the principal phyla, orders and families, and thus systematics becomes essential to the presentation of the diversity of plants and animals in an orderly and evolutionary manner. Obviously, frequent and extensive field trips are highly necessary if the teacher is to become familiar with the major groups of plants and animals and their distribution relative to environment. As more and more field work is done systematics becomes increasingly important to him in understanding classification and evolution. In this sense plant systematics serves the same needs in teacher training as animal systematics. The real diversity of plants and animals, however, does not become apparent until their morphology, anatomy or structure are compared. Thus, comparative morphology becomes essential to the teacher as a basis for understanding function or physiology, development, taxonomy and evolution. This is equally true for plants and animals.

Although the basic principles of growth and reproduction insofar as they involve cell multiplication, differentiation and fusion are the same in plants and animals, the development, differentiation and maturation of the individual varies in the two groups. Therefore, as regards to the study of plants, the development and life cycle of a representative of each phylum should be included in a biology course. Special emphasis should be given to the alternation of gametophytic and sporophytic generations and its significance in evolution. Consideration of growth and reproduction in plants should include, as far as time permits, the widespread occurrence and variations of a sexual development, of fruits and seeds and their importance as food, and the significance of secondary growth in angiosperms relative to man's development.

Plant physiology is as essential in the training of a biology teacher as animal physiology. Although the basic principles are the same in both, plant physiology is necessary to an understanding of how plants make food for man, the intake of water and minerals and their transportation, the transformation of radiant light to potential energy, respiration and the breakdown of sugars, and the storage of energy in more complex substances on which man and animals are dependent. The presence and action of phytohormones in relation to tropisms, nastic movements, etiolation and photoperiodism and their economic significance in fruit setting and dropping, parthenocarpy, weed killing, etc., certainly belong in the realm of plant physiology.

However, these should be presented jointly with a consideration of the animal hormones in explaining the unity, regulation and coordination of the simple or highly differentiated organism.

Evolution is said to be the great unifying principle in biology. Certainly, the evolution of plants is closely related to that of animals, particularly the angiosperms and mammals. Accordingly, no complete picture of the history of the past and the interrelations of the present biological world can be presented without a knowledge of both. Therefore, they should not be taught separately but side by side and closely integrated to show the evolutionary relationship of plants and man. To do this effectively the biology teacher must, of course, be as familiar with the evolution of plants as with that of animals.

Training in genetics is obviously essential to all biology teachers. Like evolution, genetics is a unifying phase of biology, and here perhaps better than anywhere else it can be shown that the fundamental principles operate in the same manner in plants and animals. Students are naturally curious about what and how they inherit from their parents, and for this reason genetics can be one of the most fascinating subjects in classroom biology. It matters little whether plant or animal material is used to demonstrate basic principles, but both types should be utilized to emphasize the universal operation of these principles.

Finally, it seems to me, the general biology course should come to ecology, the relation of plants to man and other animals, and their relation in turn to their physical environment, and man's position as part of community of living things which he dominates and attempts to control. Ecology integrates the biological and physical sciences, and in a real sense bridges the gap between them because it involves chemistry, physics, geography, geology, mathematics, meteorology and soil science as well as taxonomy, morphology, anatomy and physiology. As such it provides the basis for understanding plant and animal distribution and adjustment to environment, and is the foundation of practical conservation. Clearly, animal ecology cannot be taught effectively apart from plant ecology because animals are dependent on plants, and a well-balanced and complete picture of ecology cannot be presented without an adequate training in both.

## Recorder's Report of Discussion on

# Plants and Man

Biology is neither botany or zoology, but an integrated science, and the integrated approach was emphasized time and time again in all discussion groups. There was complete agreement on the value of selecting materials from both botany and zoology wherever possible, and showing their relation, because this relationship is true biology. There was agreement, too, regarding the difficulty of carrying through with this plan in all topics. Selection of material can be based on that which lends itself best to the topic, is most appropriate and most convenient for the teacher. The study of protoplasm and the cell offers excellent opportunity for the integrated approach, but in dealing with the taxonomy and morphology, for example, there is a parting from this approach for a time.

The matter of integrating botany and zoology, of showing interrelationships should not be entirely left to the student. The teacher should guide toward the integration. For example, it was suggested that in the discussion of cell structure and function, one group of students might give their attention to animal cells, while a second group might study plant cells. Following the pooling of information derived from this study, with the help of the instructor, the class can arrive at generalizations regarding the structure and function of cells.

Studying a specific organism in its entirety or studying a particular function as it operates in both plants and animals may appear to represent two diverse points of view. But it was accepted that there is room for both procedures—that is feasible to cover both aspects, sometimes integrating botany and zoology and sometimes studying the organism as a whole and somewhat apart from other organisms. This is especially true in the area of classification where teachers may use both the above approaches. It should be evident that the easi-

est way to teach is not always the best way for the students.

In the discussion of specific techniques for understanding certain concepts it was generally recommended that it is necessary to provide as many first hand experiences as possible. We are apt to forget that as we go from elementary school through high school and college, valuable learning takes place through experiences. It is very important to emphasize experiences in the field and in the laboratory, using living material as often as possible.

In addition to the desire for as much integration of botany and zoology as possible, or perhaps because of it, there is constant need to emphasize interaction and interdependence of living things. Content from areas other than botany and zoology also must be included. Because of the general nature of biology, the biology teacher must see a broad picture. To achieve the broad background, necessary for the successful teaching of biology, he should always remain a student whether he takes courses or not.

Despite different points of view on how to teach and what to emphasize, there was general group agreement on the need to help students understand. The ability for teacher and students to communicate was emphasized time and again. Well-prepared, essay-type tests can show whether a student can verbalize and whether he has an understanding of the material read or presented. In discussing the teaching of fundamental principles, rather than just striving to present factual knowledge, the differences and similarities in teaching procedures were brought out. *Teachers owe students more than just facts.*

Attention of all groups was centered upon the topics of protoplasm, photosynthesis, classification and evolution. To gain an understanding of many plant processes some knowledge of chemistry is needed. This is especially pertinent to the appreciation of energy relations. The need for a source of energy leads to the study of metabolism which, though different in plants and animals, performs essentially the same function. In teaching these topics, the biology teacher should present sufficient chemistry along with the biological content. Respiration in plants gives some difficulty too, because of the loose use of the term, the misconceptions, and its confusion with photosynthesis.

The concept of species is man's judgment, as is his classification of living things; but the basis of this arrangement, the important principles upon which it rests, needs clarification for the student. It was recommended that taxonomy, or rather systematics, should be taught as extensively as needed for balance, and as time permits. It is possible to highlight the economic significance of plants by selecting a familiar food plant whenever possible, to illustrate the different groups in the study of classification. The fact that 62% of our drugs are extracted from plants has significance for students who, because of recent publicity, may have the misconception that synthetics have replaced natural material.

Evolution presents a problem to many teachers when it is developed as a specific topic. This is not apparent when evolution is used as a basis for teaching classification or as the theme in the development of broad topics. The student's ability to do critical thinking to a point where it is sufficient to adequately handle controversial biological issues is one of the biology teacher's goals. A wealth of available material, class discussions based on investigation of this material, and resource people are mentioned as possible procedures that might lead toward this goal.

It was reported that substitution of such terms as progressive development or developmental changes seemed to eliminate the antagonism to the use of the word evolution.

Terminology in biology was recognized as a difficult hurdle for students but though technical terms can be reduced to a minimum, certain words are needed as working tools. It was suggested that purpose determine the selection of those which need to be taught. Adequately defined when first presented, they should then be used frequently.

Biology is spread too thinly if one attempts to cover the whole field. The alternative is the selection of fewer problems for more intensive study, at the same time giving as complete a picture as possible within the limitation of time.

MURIEL BEUSCHLEIN,
Chicago Teachers College
*Recorder*

# The Food Supply of Man

HARRY J. FULLER
Professor of Botany
University of Illinois

The provision of adequate supplies of food for the earth's rapidly increasing human population is one of the major problems of biology. The rapid progress of the medical sciences in the conquest of human diseases is contributing directly to a lengthened human life span, the decrease of infant mortality, and, as a consequence, to a tremendous growth rate of human population. It has been estimated that the earth's human population is now increasing by 80,000 per day. In many nations (e.g., India and China), the human population pressure is so great that many thousands of their citizens spend all their lives on a subsistence diet which is both qualitatively and quantitatively inadequate. With further advances in the conquest of disease, the earth's human population may be expected to increase even more rapidly than it has during the past century. This further growth will necessitate a great increase in the production of grains, vegetables, fruits, meat, dairy products, and other types of food for human use. Failure of science to provide such food increases will doubtless lead to further demands for *Lebensraum* and will inevitably produce grave international crises of a social, political, and military nature.

The study of this problem of earth's food supply is a logical and desirable part of courses in biology at the high-school level. Its inclusion in such courses presupposes the availability of suitably trained teachers to handle this subject with both scientific accuracy and the ability to stimulate student interest in this problem and its indicated solutions, insofar as solutions are possible. Thus, the foundation-stone in this biological structure is the training of young people who will become superior teachers of biology.

*Essential Subject Matter for the Preparation of High School Biology Teachers*

It must be recognized at the outset that no college or university engaged in the training of teachers can impart to their students *all* the information, *all* the attitudes, *all* the techniques which they must have to become superior and successful teachers. Colleges and universities can give to students certain fundamental facts and can induce in them certain habits and attitudes of thought and certain interests which will form the basic stock-in-trade of would-be teachers. Equipped with these, the teacher must, if he is to be a wise and percipient teacher, build upon the foundation of facts and attitudes which he has acquired as an undergraduate student. This post-college growth may develop in several ways: through memberships in biological organizations and attendance at their meetings, through a definite program of reading new biological books and biological periodicals, through travel, through summer work in commercial organizations engaged in biological work, through a continuing interest in fields such as anthropology, sociology, and geography, and through occasional college refresher courses in biological and related sciences.

An attempt to construct a list of specific college courses intended to provide the proper training of potential teachers for the teaching of specific biological topics, such as this one, must be undertaken with caution and with some reservations, for such an attempt may lead to a failure to understand the relationship between pure science and applied science. One of the most important educational ideas for a teacher to grasp and for him to plant in the minds of his students is this: that the applications

Important food plants of Old World origin. (Photo by Chicago Natural History Museum.)

of science are, in the final analysis, the extensions of pure science discoveries to immediate human problems, discoveries made by men who have sought to explain the phenomena and the objects which surround them and who have not been attempting *de novo* to invent light bulbs, antibiotics, weed-killers, and atomic bombs. The continued solution of practical problems by science can be maintained only so long as pure science research is supported and encouraged; since much of this support and encouragement is derived from public funds, every citizen of a democracy, who presumably has some voice in the expenditure of public money, should clearly understand the relationship between the pure sciences, which are substantive, and the applied sciences, which are largely derivative.

This important idea should be emphasized in the selection of courses for the training of teachers. A teacher who has had a variety of fundamental materials in the pure sciences and who has learned, in the study of these topics, to associate facts and ideas and to search out the relationships of materials learned in these to practical applications has received a much better preparation, in my opinion, than a teacher whose training has been largely in highly specialized, fragmented, utilitarian courses in the applied sciences.

The student who is preparing to become a teacher of biology obviously should have as many basic courses in biological sciences as he can fit into his college program—botany, zoology, bacteriology, entomology, physiology—together with courses in other sciences: physical sciences, horticulture, geography, anthropology, and others. The better trained a teacher is in subject matter, the more enthusiastic and the more stimulating he is likely to be in his teaching. In arranging programs of courses for students preparing to teach biology, however, we should avoid a degree of concentration in biological and other scientific subjects which would lead to educational unbalance. The teacher trainee, whether he is to teach biology or physical science or languages or art, should have suitable courses in the humanities and in the social studies to insure that he becomes educated, not merely trained. I believe that the total amount of work in sciences, plus the required courses in education for certification, should not exceed two-thirds of the total amount of undergraduate course work completed by a student preparing to become a biology teacher.

For a teacher to handle adequately the subject of the food supply of man in his classroom, he should have essentially the same

group of college courses as he would need to teach other biological topics, such as plants and man, human physiology, inheritance, and conservation. He should have solid, fundamental courses in general botany and general zoology, in the morphology, classification, and identification of living organisms, in genetics, in ecology and conservation, in physiology and health, in geography, in basic physical sciences, and, whenever possible, in anthropology and horticulture. The ability of a teacher to teach the topics considered in this conference is related only in part to the biological science courses which he has completed as a student; his effective teaching of these topics is related also to his attitudes of thought, his ability to reorganize biological information into new patterns, his pursuit of up-to-the-minute knowledge as it becomes available in new books and in current scientific journals, and his imagination and inventiveness. Without these latter qualities, no teacher, even with the most formidable array of college courses in his educational background, can succeed in the effective teaching of topics such as those considered at this conference. It should be emphasized that it is not always necessary for would-be teachers to have courses in all the subjects listed above; the essential consideration is that he have knowledge of these fields, knowledge which he can often gain through avenues other than formal courses, that is, through science clubs, through lectures by visiting scientists, and through summer work in business or in governmental agencies. The personality, the interests, and the educational background of his professors are important in determining the types of materials of which a student is exposed; thus, some professors of biological sciences weave much anthropological material into such courses as genetics, economic botany, human physiology, and general biology, so that a student in their courses might need no formal course in anthropology.

### *Recent Scientific Developments in the Area of Food Supply of Man*

Biological scientists (and other types of scientists, such as engineers), aware that one of the world's major practical problems is the increase in supplies of food for man, have devoted time, money, and research efforts to this problem and are prosecuting investigations in a number of fields, among which are these:

1. *The development of crop varieties of superior yield-capacity through plant breeding and selection.*

Investigations of this type involve the continuing search for individual plants of superior types in both domestic and wild populations and the cross-breeding of different varieties of plants in an effort to bring together in new strains or varieties increased yields, increase resistance to diseases (as a result of which increased yields occur), improved taste, and other desirable traits. That such research has already resulted in remarkable increases in crop yields is shown by an examination of agricultural statistics for various kinds of crop plants. Thus, for example, the average annual yield of corn per acre in Illinois before the introduction of hybrid corn was 34 bushels (average of yields 1910-1915); at present, the average annual acre yield of hybrid corn in Illinois is about 60 bushels. Under especially favorable soil and climatic conditions, hybrid corn yields of 120 to 140 bushels per acre have been secured, and under optimal conditions of soil fertility, temperature, and moisture, yields of more than 250 bushels of corn have been obtained per acre from hybrid seed. (Such yields are economically impractical at present because of the large amounts of fertilizers required for them). One agronomist has reported that the use of hybrid corn in 10 countries of western Europe in 1952 increased yields by 273,000 tons and that the potential increase from the use of hybrid corn in these countries is at least 4 million tons. He has reported further that the present average annual acre yield of corn in all countries outside the U. S. is 19 bushels. Similarly, wheat breeding programs have resulted in significant yield increases; in Illinois in 1895-1898, the average annual acre yield of wheat was 11 bushels, in 1935-1938, 19 bushels per acre. Some newly developed varieties of wheat yield 55 bushels per acre under optimal cultural conditions. Similar increases in yields have been produced in many other crops which have received the devoted attention of plant breeders: sugar cane, rice, various fruits and vegetables, etc. Since scien-

Important food plants of New World origin. (Photo by Chicago Natural History Museum.)

tific plant breeding is little more than half a century old, further research of this type will certainly result in even greater yields of these crops and of many other crops which have thus far received little or no attention from plant breeders.

*2. The development of animal varieties of superior yield-capacity through breeding, selection, and improved animal feeding.*

Scientific breeding of domesticated animals and improved knowledge of animal physiology have led to significant increases in meat and milk production. At present, for example, yearling steers of certain types are ready for butchering, in contrast to an earlier situation in which steers had to be two or three years old to be used for satisfactory meat production. This shortening of the time span required for meat production means, of course, that smaller amounts of grain are needed for feeding. A half century ago, 450 pounds of corn were needed for each 100 pound gain in weight of hogs; at present, this figure has been cut to 280-300 pounds of corn per 100 pounds gain. Similarly, great strides have been made in developing types of hens of greatly increased meat-producing and egg-laying capacity and increasing milk production by dairy cows.

3. *Weed Control*

Weeds compete with crop plants for space, for water, for soil nutrients, and for light, and thus their unchecked growth results in diminished crop yields. Recent advances in the development and use of chemical weed killers have contributed to greatly increased yields of many field and garden crops.

4. *Insect and rodent control*

Many types of insects and rodents feed upon crop plants, and upon their products and thus reduce supplies of grains, fruits, and vegetables. Progress in the development of effective dusts, sprays, and other chemicals by economic entomologists and zoologists has resulted in increasingly effective control of destructive insects and of rodents and thus in augmented crop yields and food supplies. As an example of the magnitude of insect damage to crops may be cited the loss of 100,000 acres of barley in Canada in August 1955 as a result of attacks of aphids on barley plants.

5. *Plant disease control*

Plant diseases, caused by bacteria, fungi, viruses, and other agents, reduce crop yields. Extensive research, especially during the last three decades, has produced sprays, dusts, seed disinfection treatments, and other practices which reduce the incidence of plant diseases and thus increase crop yields. Further, plant breeding investigations have resulted in the development of disease-resistant varieties of crop plants, which produce higher yields than susceptible varieties. In this connection it should be emphasized that the development of disease-resistant strains of plants does not confer permanent benefits, for the pathogenic organisms responsible for diseases undergo mutations and other types of genetic changes, with the result that new types of pathogens develop which, after a time, attack the disease-resistant host plant. Thus, the breeding and selection of disease-resistant strains of plants is a continuing process, one which does not solve a problem permanently but which inevitably produces other problems.

6. *Increased knowledge of plant nutrition and of soil structure and behavior.*

During the past quarter century, great strides have been made in our knowledge of crop-plant nutrition, in the preparation of fertilizers, in soil testing, and in soil management. Improved fertilizers and improved soil management programs have resulted in increased yields of valuable food-producing crop plants.

7. *Introduction of new crop plants.*

The introduction of various crops into parts of the world in which these crops are not indigenous has often resulted in agricultural benefits. Thus, the introduction of soybeans (natives of China) into the U.S., the introduction of pineapples (native of tropical America) into Hawaii, the introduction of sugar cane and bananas (natives of southeastern Asia and offshore islands) into tropical America have resulted in marked improvements in agricultural productivity in these parts of the world into which they have been introduced. The possibilities of increasing food yields through the introduction of new crops into various parts of the world, particularly crops which have thus far received little attention from plant breeders, are extremely promising. Relatively little work, for example, has been done in the breeding and selection of most tropical fruits for improved quality and increased yields, or in the little-known highly nutritious, Andean grains, quinoa and milmi. Often the introduction of a cultivated plant into a new part of the world stimulates the interest of plant breeders, with the result that an intensive program of study and of improvement of that species develops.

8. *Conversion of arid lands into agricultural areas and improvement of soils.*

Vast regions of the earth's land masses are unsuited to agriculture chiefly because of their aridity. Many of these areas have soils of such structure and nutrient content that they could support a flourishing and productive agriculture if they received adequate supplies of moisture, e.g., thousands of square miles of western and southwestern U.S., of the west coast of South America, of central and north Africa, of the middle East, and of central Asia. The construction of dams to impound water for irrigation has already made the desert bloom in many parts of California, Arizona, New Mexico, Utah, and other western states. Expansion of such water-storing projects in other arid regions of the world will greatly increase man's food supply. Increased food production will also result from the improvement of the physical structure of such soils through the addition of organic matter and possibly of soil conditioners, which induce beneficial changes in soil structure.

9. *Improved soil conservation methods.*

Increased yields of food crops may be expected also from improved methods of handing and conserving soils: improved methods of cultivation, more contour cultivation, terracing, drainage, grass-interplanting and other techniques of reducing soil erosion by rain and wind action.

10. *Increased utilization of food products from lower plants.*

Students of photosynthesis, the basic process of food manufacture in green plants, estimate that the total photosynthetic activity of aquatic plants of the world's seas may exceed the total photosynthesis of all land plants by ten times. Man's chief use of this tremendous

marine photosynthetic activity has been—and still is— in the form of the flesh of sea animals (fish, crabs, lobsters, oysters, shrimp, etc.) which derive their nourishment from sea plants. Thus far, man has made relatively little direct use of these marine plants (chiefly algae) in his diet. Inhabitants of the costal regions of New England, China, Japan, India, and the British Isles have for several centuries included various types of seaweeds in their diets, but the total amounts of seaweeds thus eaten have constituted only a minute part of the diet of the human race. In recent years the attention of scientists, especially in Japan and in the United States has been increasingly focused upon algae as potentially important direct sources of food in human diets. So important are algae as possible food sources for man that various United States governmental agencies are granting financial subsidies to promote research both in our country and in Japan on food production by algae. It is certain that investigations of the nutritional properties of algae in human diets and the direct use of algae in soups and as vegetables will increase rapidly as the problem of adequate food supplies for earth's increasing human population becomes more acute.

11. *Recent developments in the study of photosynthesis.*

One of the major objectives of investigators of photosynthesis is the elucidation of the intricate physico-chemical steps in the conversion of carbon dioxide and water by the mechanism of chlorophyll in the presence of light energy into food. Research progress in this difficult field, although it has proceeded slowly, is steadily reducing the mystery of photosynthesis and is explaining in physico-chemical terms the individual reactions of this process. If and when all these intricacies are understood and explained, it may become possible to produce sugars from carbon dioxide and water in factories, without the participation of green plant tissues in the process. This does not mean, of course, that our dependence upon our grain, fruit, and vegetable crops as food sources is likely to decrease; rather, it means that factory-production of foods on a large scale may one day supplement the manufacture of foods by green plants and may thus contribute to providing adequate supplies of food for a human population vastly greater than the estimated 2,500,000,000 persons who now inhabit the earth.

12. *Changing social and religious attitudes.* It is possible that, with further growth of human population, certain attitudes toward birth control and food taboos may undergo change. In India, for example, where food supplies are short in relation to the total population, thousands of sacred cattle roam the countryside but are never used as a source of food because of the taboo against eating their flesh. Changing attitudes toward birth control and wider dissemination of birth control information can result in a check upon the rate of increase of human populations and thus can reduce the disparity between food supplies and human numbers in certain over-populated areas. Since the total amount of food which earth can produce will be limited by the total amount of solar energy reaching the earth's surface, there will come a time when no further increase of food supplies will be possible. Thus, some sort of birth control will eventually become necessary as a check on the human population.

### *Experiences and Methods by Which Such Content May Be Transmitted to Students*

In accordance with the important fact that applications of science to the solution to practical problems are based upon pure science discoveries, the work of high school students on the subject of the food supply of man should begin with basic experiments and observations on food manufacture by plants and on the nutrition of animals. Many aspects of this general topic of food supply will, of course, be inappropriate to laboratory work and to demonstrations by teachers, and will instead involve library work, outside reading in newspapers and current magazines, the writing of papers, the exhibition of films, and other educational techniques. The types of experiences which will reinforce this subject, then, may be separated into two categories: A. Laboratory and demonstration work. B. Non-Laboratory work.

A. *Laboratory work.*

Limitations of space do not permit a detailed description of suitable individual and group experiments and of demonstrations (de-

tailed descriptions of these may be found in some of the references at the end of this article). Teachers will be generally familar with these; their inclusion here, therefore, is intended simply to indicate the principal experiments and demonstrations appropriate to this subject.

1. Experiments on nutrition of crop plants (e.g., tomatoes, corn, beans).
   a. The growth of plants in water-cultures or sand-cultures containing all essential soil elements.
   b. The growth of plants in water-cultures or sand-cultures lacking one or more essential soil elements.
   c. Experiments demonstrating the role of light in photosynthesis.
   d. Experiments demonstrating the role of chlorophyll in photosynthesis.
   e. Demonstration of the release of oxygen in photosynthesis.
   f. Demonstration of effects of fertilizers on growth of potted plants.
2. Experiments on nutrition of algae.
   a. Growth of *Chlorella* or other fresh-water algae in nutrient solutions.
3. Demonstrations of food storage and food transformations within plant tissues.
   a. Chemical tests of various plant parts for sugars, starch, fat, and proteins.
   b. Chemical tests on immature and mature plant parts (e.g., "milk stage" corn and mature corn grains, green bananas and ripe bananas) to demonstrate conversion of sugars into starch and of starch into sugars.
4. Experiments on nutrition of animals.
   a. Maintenance of laboratory animals (e.g., white mice) on full balanced diets.
   b. Maintenance of laboratory animals on diets deficient in fats, carbohydrates, proteins, vitamins.

B. *Non-laboratory work.*

Work of this type involves the use of library books, journals and other reference sources in the preparation of:

1. Written papers.
2. Talks by students before classes and science clubs.
3. Question periods and discussions following such talks.
4. Talks to classes by visitors: plant breeders, agronomists, animal scientists, agricultural chemists, and others from universities, United States governmental agencies, state agencies, seed companies, meat-packing companies, fertilizer factories, etc.
5. Use of charts, maps, graphs, etc. illustrating human populations of different countries, agricultural areas, levels of agriculture, crop imports and exports, etc.

Significant topics for papers, talks, and class discussions by students are:

1. The origin of cultivated plants.
2. The origin of domesticated animals.
3. The improvement of food plants by breeding and selection.
4. The improvement of meat-producing animals by breeding and selection.
5. The improvement of milk-producing animals by breeding and selection.
6. The history and importance of plant introduction.
7. Plant introduction policies and practices of the United States Department of Agriculture.
8. The relationship of control of human diseases to human population growth.
9. Agricultural production in different countries (the surplus countries and the shortage countries).
10. Algae as sources of human foodstuffs.
11. The utilization of aquatic animals as sources of human foodstuffs.
12. Fisheries research in the United States.
13. Weed control and its effects upon agricultural yields.
14. The control of plant diseases and its effect upon agricultural yields.
15. The production, improvement, and agricultural effects of fertilizers.
16. Soil conditioners and their effects upon soils.
17. Biological and chemical control of insects which attack crop plants.
18. Arable lands of the world compared with non-arable lands.
19. The history of irrigation.
20. Effects of irrigation upon agricultural production in the U. S.
21. Irrigation practices and possibilities in countries other than the U. S.

Non-laboratory work involves also the use of suitable motion pictures and slides illustrating agricultural methods for different kinds of crops, agricultural procedures in different countries, human diets and nutrition, crop improvement, soil conservation and management, and related topics.

*Important Generalizations for Students.*

In addition to their learning and understanding the basic facts involved in the food supply of man, students should become aware of certain generalizations which apply not only to this specific topic but to other scientific topics as well. It thus becomes an educational obligation of the teacher to point out these generalizations to students, or, preferably, to stimulate his students to discover these generalizations on their own. Among these important generalizations are the following:

1. The economically-valuable applications of science to problems of human life are basically the consequence of pure-science research.

2. Sciences are not tightly compartmentalized but are intimately related with each other and with other fields of human knowledge. Thus, a meaningful study of man's food supply involves not merely the study of botany, zoology, and the agricultural sciences but inevitably requires some consideration of economics, sociology, human history, medical science, and anthropology.

3. Only very rarely is the solution of a human problem by science an eternal and complete solution. Scientific solutions of problems are usually partial solutions, which, as they develop, commonly create other, often unexpected problems, which must then be solved in their turn.

4. Biological phenomena in nature are so intricately inter-related that the alteration of such phenomena by man is commonly followed by changes in other biological events. Thus, the extensive use of DDT and of other insecticides to kill mosquitoes which carry malarial parasites may influence crop yields in the area as a result of their destruction of flower-pollinating insects.

*Some Important References for This Topic*

1. Anderson, Edgar—Plants, Man, and Life. Little-Brown, 1954.
2. Black, J. D.—Food Enough. Cattell, 1943.
3. Castro, J. de—The Geography of Hunger. Little-Brown, 1952.
4. Chapman, V. H.—Seaweeds and Their Uses. Maxwell and Springer, 1950.
5. DeKruif. Paul—Hunger Fighters. Harcourt, Brace, 1928.
6. Duncan, A. C.—Food Processing. G. T. Smith, 1943.
7. Dunn, L. C.—Genetics in the Twentieth Century. Macmillan, 1951.
8. Gras, Norman—History of Agriculture in Europe and the United States. Appleton-Century-Crofts, 1944.
9. Hill, A. F.—Economic Botany (2nd ed.) McGraw-Hill, 1952.
10. Klose, N.—America's Crop Heritage. Iowa State College Press, 1950.
11. Lush, Jay L.—Animal Breeding Plans. The Collegiate Press (Ames, Iowa), 1947.
12. Miller, D. F. and G. W. Blaydes—Materials and Methods for Teaching Biological Sciences. McGraw-Hill, 1938.
13. Russell, E. J.—World Population and Food Supply. Allen and Unwin, 1954.
14. Russell, E. J.—Soil Conditions and Plant Growth. Longmans, Green, 1950.
15. Schultz, T. W.—Food for the World. University of Chicago Press, 1945.
16. Sears, P. B.—Deserts on the March. University of Oklahoma Press, 1935.
17. Storer, John H.—The Web of Life. Devin-Adair, 1953.
18. Tiffany, L. H.—Algae, the Grass of Many Waters. C. C. Thomas, 1938.
19. Vavilov, N. I.—The Origin, Variation, Immunity, and Breeding of Cultivated Plants. Chronica Botanica, 1951.
20. Vogt, William—The Road to Survival. Sloan, 1948.
21. Walker, C. L.—Man and Food; the Lost Equation? Foreign Policy Association, 1949.
22. Wilson, C. M. et al.—New Crops for the New World. Macmillan, 1945.
23. Reports of the Food and Agricultural Organization of United Nations.
24. U. S. Department of Agriculture Yearbooks of Agriculture—A series of volumes published annually on Crops, Insects, Grass, Plant Diseases, Farmers in A Changing World, etc.

### Recorder's Report of Discussion on

# The Food Supply of Man

The extended human life span achieved by advances in medical science and the general improvement of human diets and living conditions is rapidly increasing earth's human population, so that many thousands of people live on inadequate diets and that population pressures are beginning to create grave economic, social, and political problems. The pro-

vision of proper amounts and kinds of food for the rapidly increasing human population should be brought to the attention of high-school students in biology courses. The new material contributed by the discussants at the conference on the training of biology teachers to distribute properly this information is as follows:

1. Teachers should become acquainted with more scientific journals and popular science magazines of good quality to keep up to date.

2. Biology teachers may often learn more from travel in biologically important areas (e.g., tropical rainforest) than from repeated attendance at university summer sessions, in-service courses, etc.

3. Teachers should attend such informal conferences as this so that they may freely exchange ideas and experiences on biological problems, such as man's food supply.

4. The development of interested and stimulating teachers is in considerable degree the result of the teaching attitudes and enthusiasms of college professors who help to train teachers.

Biology teachers should receive new ideas to use in their classes from sessions like these, from journals, and from travel. This will help them in presenting new information and techniques on increasing man's food supply on a larger scale to help solve those problems arising from rapid population increase. Some suggested topics are:

1. Rodent control.

2. Local conservation projects, emphasizing soil conservation and maintenance of soil fertility.

3. More cosmopolitan attitudes toward food and eating habits.

4. Reclamation projects to irrigate lands now too arid for food production.

5. Improvement of crop yields through breeding, selection, and other biological methods.

Discussions were held on the proper placement of such topics in school levels, and the following suggestions were made:

1. The introduction of this general topic should be made in the lower grades.

2. There was general agreement that special units on this topic were probably not necessary, because various aspects of this subject could be introduced into the study of: a. Photosynthesis. b. Conservation. c. Insects and fungi.

3. These various aspects, treated separately in connection with such topics, might be drawn together in an ecological unit in summary fashion, for the whole problem of man's food supply is basically an ecological problem.

Some handicaps to adequate food distribution on a world-wide basis were pointed out:

1. Economic problems related to shift of food supplies from have-countries to have-not countries; problems of payment, of economic exchange, of reduction of surpluses of some areas and the distribution of such surpluses to have-not areas.

2. Problems of crop-disease introduction and spread.

3. Psychological, religious, and ethical attitudes which often create food taboos.

Teaching difficulties, opportunities, and methods by which content may be transmitted to students were listed, as follows:

A. Teaching difficulties.

1. Trespassing upon social studies.

2. Some of the problems involved are extremely complex; when world political and economic leaders have been unable to solve some of these problems, it is difficult to conduct satisfying studies of these problems at the high-school level.

3. Cut-and-dried, mass-production workbooks often given no opportunity for adequate treatment of such complex topics as food supply.

4. Under crowded classroom conditions, it is often difficult to avoid straight textbook teaching, which is not well-designed for teaching this topic.

B. Teaching opportunities.

1. Motivation is simple in this important and familiar area.

2. Integration of biological with geographical, meteorological, and other materials is simple.

3. Demonstration that application of scientific principles and discoveries is not inherently simple but that it is frequently complicated by social attitudes and problems.

4. Opportunity to demonstrate an important principle, namely, that applied science inevitably grows out of pure science research.

5. Opportunity to demonstrate that ultimately human survival may depend upon solution of the problems of increasing world's food supplies.

C. Teaching methods.

1. Audio-visual aids.

These include a number of items in addition to the traditional slides and films, such as the blackboard, the microscope, microprojector, and actual specimens. Danger in over-use of films; films should be limited in their use and should be employed chiefly to demonstrate materials which cannot be suitably demonstrated in any other way. Many films now available contain scientific errors. NABT might be able to do something about production of films of higher quality and accuracy.

2. Research projects.

Among such projects for individual or group work by students are:

a. Study of what has been accomplished in increasing crop yields, e.g., in hybrid corn.

b. Study of diets.

c. Study of food chains, pyramids, and cycles.

3. Field trips.

a. To farms and slaughter houses.

b. To dairies and creameries.

c. To grocery stores.

d. To gardens, especially school food gardens.

4. Junior science projects.

5. Local conservation projects.

The consensus was that teaching methods depend upon the teacher. We must have greater coordination of biology with other subjects to develop major concepts and suggested solutions of the problem of the world's food supply. Biology teachers have an obligation to bring into their teaching other topics which may be related to purely biological topics. They must, for example, relate biological facts and principles and problems to economic and social fields when such relationships are indicated. In teaching topics which have connections with human social attitudes, economic outlooks, and philosophical values, teachers must handle these connections adroitly and without giving offense and at the same time must avoid the sacrifice of scientific truth and accuracy.

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LEADERS FOR PART I

*First Row* (left to right): John Karling, Consultant and Recorders Beuschlein, Higbee, Larsen, Paulson and Conyers.
*Second Row:* Chairman John Behnke, and Consultants Fuller, Bowman, Goodman and Dana.
*Third Row:* Chairmen Charles, Jeffers, Stork and Klinge.

# Human Genetics

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Without suggesting that human genetics be *the* indispensable course in any high school teacher's curriculum, for several reasons the subject deserves high priority among the possible disciplines a teacher might elect to study. The fact that much of high school biology is centered around man recommends the study of human genetics as a necessary part of a balanced understanding of human biology. Further, any study of human health is incomplete without considering the individual's genotype or the population's genetic composition. The force of the preceding argument will tend to become greater with the ever-increasing relaxation of selection pressures in human populations and with our increasing knowledge of heredity. Finally, if part of effective pedagogy includes capitalizing on the native interest of the student, human genetics is desirable subject matter, holding, as it does, great interest for both the high school and the college student.

Presuming that human genetics is to be a part of the high school biology course, we may then ask what might constitute adequate teaching training in this area. There is, of course, some knowledge necessary for understanding heredity at any level of competency. A minimal core would include elementary transmission genetics, i.e., Mendel's laws, polygenic inheritance, multiple alleles, autosomal and sex-linkage, mutations, and the relating of the foregoing to the structure and behavior of the chromosomes.

In addition to these basic genetic principles, the student should be acquainted with the unique problems in human heredity resulting from human habits of reproduction and the impossibility of performing breeding experiments. More specifically, the student should acquire some knowledge of the theory and practice of determining the heritability of human traits. Classic Mendelian ratios are rarely observed in human pedigrees both because of the small average size of human families and because of frequent biases in the selection of families to be studied. The small average size of today's families leads to relatively large random deviations between the number of persons one expects to exhibit a particular trait in a single family, and the number observed to have the trait. For example, if a normal man and his normal wife both happen to be heterozygous for albinism, they may expect one-fourth of their children to be born albinotic. Hence, if they plan on a four-child family, one child would be expected to be an albino. However, among *all* four-child families with parents of the same genotype as the foregoing, 26 per cent will have, by chance, two or more albinotic offspring. This hypothetical case may be followed further to illustrate one type of bias in the selection of families we might include in a study. Since we cannot at present determine which parents are heterozygous for the gene producing albinism, we detect them only when they have already produced one albinotic child. Thus, children from one child families included will *all* be albinos. For the same reason, the families in which both parents were heterozygous, but who by chance have produced four normal children, would be omitted from our study. Correcting for these unavoidable omissions, among all four-child families which we could observe we would expect that 38 per cent of them would include two or more affected offspring. Finally, if we sum all the normal and affected children in these four-child families, we would expect to find 36 per cent of the total to be

albinotic rather than the classic Mendelian 25 per cent. Reed (1955) includes the Macklin method for making such corrections. The considerations above do not abrogate the fact that a man and wife, both heterozygous for the gene producing albinism, have one-in-four chance of producing an albino child with each pregnancy.

The corrected expectancies cited above are all based on an expansion of the bionomial, a fact which leads to the suggestion that any student who has not had prior training be introduced to some of the elementary principles of statistics to the extent that they prove necessary to a course in genetics. A rigorous mathematical treatment of genetics is obviously not feasible in an elementary course, and it is anticipated that an instructor will adopt an approach keyed to his students' degree of sophistication.

Population genetics should be an integral part of a course in general or human genetics. Population genetics is the study of the mechanisms whereby the relative frequency of two (or more) contrasting alleles is maintained in equilibrium or altered through the agencies of mutation, selection, migration, and random gene fluctuations. This recently developed area forms the fundamental basis for understanding evolution and its stepchildren, taxonomy and speciation. The fact that many high school courses and textbooks of biology use evolution as one of their major themes provides ample justification for teaching population genetics in an elementary genetics course which prospective high school teachers might take. Stern (1949) clearly presents the basic principles applied to human populations. Additional time should be devoted to twin studies, consanguinity, the detection of heterozygotes, the fascinating fields of physiological and developmental genetics, and the age-old and often misunderstood problem of the relationship between heredity and environment. These suggestions should not be interpreted as absolute minimal requirements, it being presumed that the teacher will be guided by his own training and experience, the time allotted for the course, and the interests of his students.

The extension of the basic concepts to medical and socio-economic problems such as mental illness, mental deficiency, and other disease states is worthwhile, but poses some practical difficulties. The principle problem is that the most common medico-social problems are not single disease entities, and, because of their diagnostic and genetic complexities, are less well understood than the better defined but less frequent hereditary abnormalities. There is value in demonstrating the applications of genetics to medico-legal problems and to counseling individual families concerning hereditary abnormalities. The broad implications of genetics in the related areas of race, immigration, eugenics, and evolution present further possibilities. As a device for increasing the breadth of the students' knowledge, one might examine the increasing symbiosis between human genetics and the fields of anthropology, medicine, and psychology. The teaching of any methods or applications should be well tempered with the recognition of their limitations and an awareness of the dangers of oversimplification. It seems apparent that without integrating some of these broader topics with the study of fundamental principals, these ramifications could be discussed only briefly.

Ideally, the sequence to be followed by a student interested in human heredity would consist of an introductory course in basic genetics followed by an additional course in human genetics. However, with the recognized need for a balance between breadth and depth in teacher training, a schedule resulting in one-third or more of a student's biological training being in genetics is unrealistic. Two alternatives are immediately apparent: (1) to provide a general genetics course which emphasizes human applications or treats the human case terminally; (2) to provide a course in human genetics which includes all necessary general genetics. The former alternative, of necessity, could treat the human aspects in only a cursory fashion, and the latter would be forced to omit from consideration many special genetic situations to be found in plants and in animals other than man. Either course should emphasize the universality of the basic principles, and, to the extent that either succeeds, the dilemma created by limited time for training is resolved. At the present time choice yields to necessity, there

being few colleges which offer human genetics without requiring a prior course in general genetics.

Considered from the standpoint of biology's contribution to daily living, genetics could be justifiably included within the curriculum of all biology teachers. One valuable by-product of training in human genetics which cannot be measured easily is the effect such training has on the teacher's recognition of the importance of individual differences. Possibly no other course more clearly documents the extensive variability to be found in human populations.

Human heredity may, of course, be taught employing lectures alone, but the possibility of the judicious use of audio-visual aids should not be overlooked. The projection of slides or the presentation of scientific and documentary motion pictures will reinforce lectures or provide experiences which have greater significance for the student when he sees as well as hears them. A well-planned field trip to a state institution such as a mental hospital will provide numerous examples of human hereditary traits, and is especially valuable if the personnel of the institution can be persuaded to present a clinical demonstration of them. Other aids to teaching are limited only by the imagination of the instructor.

An annotated list of some of the current books useful for self instruction, teaching, or research in human genetics is appended for the interested reader. High school students will be able to make use of some of these references. Because the reading skill and biological background needed for understanding them varies widely from one book to another, the teacher's evaluation of the materials should precede any assignments.

In summary, the study of human genetics has practical value for any prospective teacher. Its brief history can be used to exemplify progress in scientific thought and to demonstrate the ever-present need for further research. Finally, after all of the technical details of such a course have been long forgotten, its study may yet contribute to the formation of attitudes both reasonable and necessary to living in today's world, crowded as it is with the highly variable groups comprising mankind.

## *Bibliography*

Boyd, W. C. 1950. Genetics and the races of man. Little, Brown & Company, Boston. One of the best accounts of man's ethnic relationships based largely on blood grouping studies.

Dunn, L. C. and Dobzhansky, T. 1946. Heredity, Race, and Society. Mentor Books, Inc., New York. An authoritative account of the significance genetics has for man as a social organism in a finite world. Though written for laity, some portions might prove difficult for the non-biologist.

Gates, R. R. 1948. Human Genetics. The Macmillan Company, New York. An encyclopedia in two volumes including references and brief descriptions of most of the world's literature in human genetics. Because of space limitations, the author does not always indicate nor evaluate the methods and criteria employed in the studies included so that for critical work one must consult the original references.

Kallmann, F. J. 1953. Heredity in Health and Mental Disorder. W. W. Norton & Company, New York. A description of what is known of the role played by heredity in mental health and disease states as revealed by twin studies conducted by the author and others. The author is both a geneticist and psychiatrist.

Muller, H. J. 1955. Genetic damage produced by radiation. Science 121:837-840. A mature view of the dangers radiation holds for man's genetic constitution. Muller, one of the earliest workers in this field, received a Nobel prize for his achievements.

Neel, J. V. and Shull, W. J. 1955. Human Heredity. University of Chicago Press. The newest American textbook in human genetics; emphasizes the statistical methods required for this area. A knowledge of calculus is helpful, though not indispensable to the reader.

Osborn, F. 1951. Preface to Eugenics. Harper and Bros., New York. The most recent authoritative book in eugenics, the area where many misconceptions still exist. Good reading for anyone interested in either the size or quality of human populations.

Penrose, L. S. 1949. The Biology of Mental Defect. Grune & Stratton, New York. This volume provides a summary of work in the field through 1948 including the author's work on Mongolism and a good account of the methods.

Race, R. R., and Sanger, R. 1950. Blood Groups in Man. Blackwell Scientific Publications, Oxford, England. Contains descriptions of the types and frequencies of blood groups in man and methods for determining them by two of the foremost authorities.

Reed, S. C. 1955. Counseling in Medical Genetics. W. B. Saunders Company, Philadelphia. A book written primarily for practicing physicians with genetic technicalities kept to a minimum; presents the current status of genetic knowledge about the most common abnormalities such as mongolism, epilepsy, nervous system malformations, clubfoot, etc.; an appendix containing risk figures and the modes of inheritance of a large number of hereditary diseases should prove useful to many.

Scheinfeld, Amram, 1950. The New You and Heredity. J. B. Lippincott Company, Philadelphia. A journalist's first-rate effort at popularizing a knowledge of heredity is presented in easily readable form. Though accurate, the book might mislead some high school students who may not yet discriminate between opinion and fact or between speculation and scientific demonstration.

Snyder, L. H. 1951. The Principles of Heredity. D. C. Heath & Company, Boston. This is one of the most popular college texts for elementary genetics courses. More than one-fourth of the book is devoted to human heredity; includes a clearly written account of population genetics applied to man.

Stern, C. 1949. Principles of Human Genetics. W. H. Freeman Company, San Francisco. Seems to be the best compromise between making human genetics understandable for the student, and accurately presenting the major principles involved. Recommended as an excellent reference for the in-service teacher who wishes a broad view of the discipline.

Winchester, A. M. 1951. Genetics. Houghton, Mifflin Company, New York. A text in general genetics emphasizing man. Some illustrations and diagrams included might prove useful for presenting genetic concepts to high school students.

## Recorder's Report of Discussion on

# Human Genetics

Group discussions on human inheritance centered around four main themes: 1) Why should human genetics be studied in high school? 2) What should the teacher have learned in order to teach this subject? 3) What concepts and information on human inheritance should the high school biology course include? 4) How can these topics be taught in an accurate, understandable, meaningful and stimulating way?

The focal object of biology is the total organism in its environment. The organism is a system in which every component and process reflects the indissoluble, but analyzable—interweaving of sets of genetic and environmental factors. To understand events at all levels of organization in living systems one must understand, among other things, the processes determining the genetic endowments of individuals, populations and species, as well as the role of genetic determiners in development and function. This principle is the basic justification for high school study of human heredity. One key objective of the course is to help the student know himself and mankind as organisms. In human biology genetics is an indispensable chapter.

In the preparation of the teacher, human genetics has a two-fold importance. His own knowledge of the field will obviously determine what he can teach. Furthermore, his job is to create school experiences, i.e., environmental conditions, which foster the full realization of his students' genetic potentialities; an acquaintance with the facts and implications of human heredity can be helpful both in the formulation of his educational philosophy and in specific classroom situations. For example, he can aid students in obtaining informed genetic counseling as well as the background understanding needed to interpret such advice.

One requisite phase of the biology teacher's preparation is a substantial treatment of general genetics, including fundamental principles of the mechanics of inheritance, developmental genetics and population genetics, together with a consideration of their implications for other biological areas and study of the exemplification of principles in all major groups of organisms. Human examples must be included. So far as known, the principle of transmission of inhereditable properties are the same in men as in other groups. However, the analysis of the mode of inheritance of specific traits requires somewhat different techniques, which the prospective teacher should understand. This requires an elementary knowledge of statistics (which is also essential for most other biological fields as well as many disciplines among the social sciences and in education). These methods have had a major role in the development of population genetics, so that human genetics provides an excellent entree into a field basic to modern analysis of biosystematics and evolutionary dynamics.

So long as this content is part of the prospective teacher's curriculum, its course placement is a matter of local institutional preference. Some first-year general biology courses elect to treat genetics rather fully as a central biological topic. More often the material forms part of an advanced general biology program or a general genetics with attention to the special case of man or a separate human heredity course which attempts also to indicate the wide applicability of the fundamental principles among organisms of all kinds.

In the high school course human genetics is properly regarded only as a case of special interest in the framework of general genetics. The aim is to develop an understanding of the basic hereditary phenomena as they operate in all organisms, to use examples from a variety of groups, but also to include some consideration of human examples and human implications.

The average high school biology course allots two to five weeks, generally the smaller number, to the genetics unit. This need not, and perhaps should not, come all in one block. The concept of variation, the distinction between genetics and environment in influencing variation, the role of mutation in the origin of inherited differences, and some implications for other areas are concepts which can be introduced early in the course, either on the basis of student familiarity with people, family lines and apparent inheritance, or from field trip observations. Even the key concepts of genetic segregation and independent assortment can be introduced at this point. However, a unit is needed for systematic treatment of transmission genetics, with some reference to developmental and populational aspects. Implications should be referred to both before and after this unit is taught. The material is often placed after consideration of the functional organization of plants and animals and before consideration of topics like evolution and ecology. A knowledge of the rudiments of population genetics and mutation is, indeed, indispensable for understanding evolutionary mechanisms.

Hybrid corn, livestock breeding, garden varieties of flowers and similar local applications of genetics may also serve to introduce the instructional unit. The students and their families provide another source of interest and material. Elementary Mendelism is perhaps best treated by careful analysis of one or a very few cases; students can then work out individually selected problems to illustrate the wide validity of the basic rules. For this purpose the teacher is advised to use the few traits for which the mode of inheritance is simple and relatively securely established and which can be identified readily, such as thumb hyperextensibility, attachment of ear lobes, curved and straight little fingers, mid-digital hair, ABO, MN, Rh blood types, PTC tasting. The students may then be encouraged to look for particular familial traits which seem to be inherited, collect pedigrees, and attempt analysis of them. This can be a useful exercise in investigative methods, since they should be led to see the hazards of basing analysis on one or a few pedigrees. At the same time, they may come up with some interesting cases deserving of further study. For it should be pointed out that human genetics is one of the youngest of the biological sciences, that its importance for medicine and other fields is growing rapidly, and that it forms a wide open career field for those who develop special interest and competence.

Biochemical and developmental genetics are probably best treated at this level with illustrations from organisms other than the human, but enough is known about a few human traits, such as sickle cell anemia, to provide a basis for study. Polygenic inheritance, variable penetrance, variable expressivity, and genic interaction may be pointed up in relation to development.

Depending upon student background, the teacher may be able to introduce a few elementary statistical concepts and computations. Because of the importance of statistics in varied fields of human endeavor, these topics can rightfully claim a place in high school instruction.

In discussing the physical basis of inheritance there is wisdom in separating the study of mitosis from that of meiosis. The former can come early in the course, when cells or micro-organisms are studied, since it is essentially a method of cell multiplication. Chromosomes, the chromosome complement, its transmission from parent to daughter cell are concepts which can be introduced at this time. In the genetics unit, after an understanding of Mendelian principles has been developed, a very simple outline of meiosis can be presented; films of the process vividly demonstrate its dynamic character. Meiosis must, of course, be referred to in gametogenesis and sporogenesis, but the actual production of reproductive cells may well be incorporated in sections on reproduction of animals and plants.

Interest in varied human populations and the fact that a fair amount of information is avaliable on the geographical distribution of

certain alleles makes man a useful object to illustrate the elementary ideas of population genetics: genetic composition of a population and the operation of mutation, selection, migration and genetic drift in determining that composition. These concepts are, of course, at the heart of an understanding of the mechanisms of evolution.

According to student interest and time available the course may consider various implications of human genetics. Examination of such still popular fallacies as maternal impression will help one appreciate how not to investigate problems and the difficulties in correct analysis. With increasing use of atomic energy and increasing possibilities of exposure to radiation, students should understand the mutagenic effect of high-energy radiation, the fact that our knowledge in this field is very limited, and the possible hazards of increasing mankind's load of deleterious mutations. A knowledge of human heredity should help students understand the role of environmental opportunity in realization of human potentialities and the real nature of human differences. Thereby he may be better equipped to appreciate men the world over in their rich and fascinating variety, their fundamental likeness and promise.

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# Health and Disease

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Almost any approach used in the teaching of biology—morphological, physiological, ecological, or other—cannot help but include important aspects of health and disease. The Southeastern Conference on Biology Teaching a year ago recognized this and contended that the biology teacher is the person best qualified to give health instruction. Thus there seems to be little need to justify giving consideration at this conference to health and disease as an essential content area of biology. However, this topic does differ from the others under consideration at this conference in that health and disease instruction may be dispersed widely in the curriculum with some of the content outside the department of biology both in the college preparation of the teacher and in the high school instructional program.

*Preparation of the Biology Teacher*

The biology teacher should be prepared to assist students in acquiring or extending their aggregate of scientifically accurate knowledge of health and disease through instruction or in the handling of classroom or school situations and in the development of desirable attitudes pertaining to personal, family, and community health problems. Furthermore, his preparation should be sufficiently adequate to enable him to make a contribution, and give leadership when necessary, to the solution of school and community health problems. In order to provide the broad background essential to perform these functions, the biology teacher should be well-prepared in five content areas: human anatomy and physiology, human growth and development, communicable diseases, non-communicable chronic diseases and common impairments, and the organization, resources, and facilities for health available in communities, states, the nation and the world.

As a foundation for any instruction in the field of health and disease a thorough understanding of *human anatomy and physiology* is essential. The knowledge of the structure, function, and integration of body tissues and systems provides a base upon which many of the necessary additional understandings can be built or related. Such a foundation also develops an overall appreciation for the complex and wonderful organism that the human body is.

To be complete this study should give full attention to the human reproductive system, so often omitted or slighted. This leads directly into a second big area of competency, that of *human growth and development*. Together these should provide understandings of normal sex relations, pregnancy, the development of the fetus, the birth process, prematurity, birth injuries and congenital defects; the physical and accompanying mental, emotional and social development during infancy, early childhood, later childhood, adolescence, and adulthood including the later years; the variations in growth patterns; and the physiological effects of exercise, rest, and sleep. Gerontology—the scientific study of the aging process and associated diseases—is competing today for a comparable place in research and in professional and public interest which child growth and development has enjoyed in more recent decades. Important new concepts with health implications are emerging.

Since food intake is such an important factor in growth and development, and may even limit reproductive ability, concepts of food and nutrition assume great significance. This necessitates thorough understanding of the essential nutrients, the composition and nutritive

The public health nurse is a resource available in many communities to assist in teaching programs. Here the public health nurse demonstrates a technique for a group of girls interested in nursing.

values of foods, food demands for normal metabolism; food-growth relationship; food demands during pregnancy and lactation; factors influencing gain and loss of weight; family food patterns; food patterns common to cultural groups; and an appreciation of the extent of malnutrition in all parts of the world especially in under-developed areas.

Related here also is the rather large and important field of mental health. A thorough understanding of the principles of mental health, motivation, the varieties of adjustive behaviour in coping with problems, intra-family and inter-personal relationships, and the technics and practices of mental hygiene is essential.

Dentition is another important phase of emphasis here, and one often neglected. Clear-cut concepts on the development and eruption of the deciduous and permanent teeth are an important base for the entire study of dental health needs.

The control of *communicable diseases* requires eternal vigilance to hold and improve upon the gains made since the early beginnings of the golden age of bacteriology. Here it is important to understand the nature of the infectious process, the defenses of the body, the mechanism of antibody-antigen reactions, kinds of immunity, recommended tests and immunization procedures and other means of prevention or control. Also basic to an understanding of the common communicable diseases is knowledge of the etiological agents, life cycles, routes of transmission, alternate hosts, and the principles of epidemiology.

The common cold, tuberculosis, and other respiratory diseases continue to be of major concern and are worthy of special attention. Venereal diseases should be considered here as

communicable diseases rather than in discussions of the reproductive system or sex relations.

Regional variations in disease control problems, the status of the disease problem and sanitation facilities in under-developed areas of the world, the need for research on control measures for parasitic diseases such as schistosomiasis and filariasis, the control precautions taken at points of entry to the country and immunizations required for foreign travel are also of consequence.

Application of these understandings to personal cleanliness and environmental sanitation for individuals, the family, and community are significant concomitant concepts. This helps explain, at least in part, the why of the daily regimen of hand-washing, bathing, care of the skin, hair, nails, and mouth; first aid procedures; and isolation of the sick. It focuses attention too on the importance of individual, family, and community concern about the manner in which the food is handled, stored, and prepared; with dishwashing procedures; with safe supplies of water, food, milk and milk products; with safe disposal of human wastes, garbage and refuse; with insect and rodent control measures; with air sanitation, with housekeeping procedures in the home, school, food establishments, recreation and resort areas, and the community at large. The importance of these procedures in disease control and comfort and convenience necessitates a thorough knowledge of the recommended practices. The significance of each individual, each family, each community, and each nation in assuming responsibility for the control of communicable diseases and sanitation should be stressed.

With an estimated one in six people in the United States and one in two in the world suffering from some form of chronic complaint or disability, knowledge of *non-communicable chronic diseases and common impairments* becomes extremely significant. While many of these diseases are present from infancy throughout life and have been recognized as problems over the years, they have taken on new importance recently as knowledge of prevention, control, and treatment has removed many of the communicable diseases from the lists of major causes of death and high incidence of morbidity in this and some other nations.

Concepts of the nature and causes, prevalence, social significance, relative importance, achievements in research, and the measures for prevention and control of chronic illnesses and impairments constitute the important understandings associated with this field.

The list of chronic illnesses and impairments is long. Some which might be included are heart and associated cardio-vascular-renal diseases, cancer, impairments resulting from accidents, mental and emotional instabilities, arthritis and rheumatism, diabetes, dental caries and periodontal diseases, malnutrition, vision and hearing defects, acne and other dermatoses, allergies, digestive disturbances, food poisonings, alcoholism, drug addiction, orthopedic handicaps, malformations, epilepsy, cerebral palsy, and muscular dystrophy.

The place of screening programs conducted in schools, industry, or the community at large in detecting chronic conditions should be understood and appreciated. No discussion of dental caries would be complete today without adequate attention to the importance of diet in dentition and the caries process and to community provisions for fluoridation of public water supplies or the topical application of sodium fluoride to control dental caries.

An understanding of the *organization, resources, and facilities for health* available in communities, states, the nation, and the world is essential to anyone carrying on health education. This includes knowledge of the provisions for organization, administration, and supervision of health; the objectives and functions of both tax-supported health agencies and those financed by voluntary contributions; the important role of the private practitioners of medicine, dentistry, nursing, veterinary medicine, sanitary engineering, and other specialities—and their professional organizations; the provisions for medical care, hospitalization, and nursing services for the sick at home; and the programs and services of health agencies such as communicable disease control, environmental sanitation, laboratory, biostatistics, health education, chronic disease, and services for special groups such

as mothers and young children, the aged, the handicapped, schools, and industry.

The story of the modern health movement in this and other industrialized areas of the world is a fascinating one. The role of lay citizens as well as professionals in its inception and development, the devotion of its leaders, and the achievements in the past century contain elements of a story that rivals that of any social movement. Today World Health Organization activities, especially those in under-developed areas of the world, are writing interesting new chapters in this story. Knowledge and appreciation of these past and current activities add interest and vitalize health instruction.

*The biology teacher is the person best qualified to give health instruction by the very nature of his broad base provided in the general biology courses.* An extension of this preparation to include the five areas above will make him eminently qualified to select content and experiences for instruction in terms of the health needs, interests, and problems of high school biology students.

Further undergraduate or graduate study which includes such sciences as embryology, genetics, biochemistry, psychology, bacteriology, virology, parasitology, pathology, epidemiology, sanitation, mycology, entomology, physiological hygiene, nutrition, environmental sanitation, and related branches and courses in personal and community health, public health, maternal and child health, mental health will provide further breadth as well as depth of understanding.

### *Health and Disease As Content For High School Biology Courses*

Since health instruction is widely dispersed in the high school curriculum and since the health needs, interests, and problems of high school students and communities will vary widely, selection of the content on health and disease to be included in the high school biology course will need to take all of these factors into consideration. It would seem impossible to teach a course in high school biology without giving attention to at least some aspects of health and disease. Beyond this the amount included may be determined by what is being well-taught elsewhere in the total school experience of the students. Whatever is to be included may be integrated with other course content or may be taught as entire units. Some suggested content for health units in biology are:[1]


One of the many duties of the public health engineer is to assure communities that water is safe for drinking and bathing purposes. Here the engineer and some of the college students are checking the safety of water in a college swimming pool.

1. The basic processes of digestion, circulation, reproduction, assimilation, respiration, excretion, sensory stimulation, and muscular response.
2. The phenomena of growth, including human development.
3. Adaptations of organisms to their environment including the biological faults in man's modern city environment, such as lack of sunshine, fresh air, and space for muscular activity.
4. The relation of man to microscopic organisms.
5. The control and prevention of many diseases.
6. A study of man's nervous and endocrine systems and their interdependence.

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[1] From: American Association of School Administrators, *Health in Schools*, p. 171.

*Experiments and Methods for Transmitting Content on Health and Disease to Students*

A complete list of experiments and methods for transmitting knowledge of health and disease to students is voluminous and cannot be included here. In general these methods can be grouped in the four categories mentioned below.

*Laboratory work and demonstrations.* Most biology teachers are acquainted with the use of live laboratory animals to demonstrate concepts such as the circulation of blood, the reproductive process, sensory stimulation, normal and deficiency diets, etc.; the use of preserved vertebrates to teach about organs and systems; simple experiments to show the nutrient content of foods, action of enzymes, growth of bacteria, transmission of bacteria, etc.; simple demonstrations to illustrate accommodation of the eye, vision defects, taste sensations, lung capacity, chest expansion, artificial respiration, effects of exercise, presence of red and white blood cells, etc.

*Visual aids.* A large number of charts, anatomical models, paper and wax food models, posters and films are available to supplement textbooks, references, and discussions about health and disease. Most teachers are aware of the number of good films available to aid in teaching the anatomy and physiology of various organs and systems. Most state health departments have film libraries from which films pertaining to personal and community health, scientific discoveries and advances, health careers, communicable and non-communicable diseases, growth and development, mental health, dental health and similar topics can be obtained.

*Community resources and facilities.* Health personnel from local or state health departments, voluntary health agencies, hospitals, or professional societies are resources which can be used to vitalize the teaching and create interest in local health problems or in careers in the health professions. They may provide demonstrations, conduct tours, or help discuss health problems.

Health educators employed by local and state health agencies are especially prepared to assist school groups in this manner. Nutritionists are well-equipped to help demonstrate and discuss food intake, meal planning, special demands of pregnancy, the diet problem, food fads, etc. The sanitary engineer or sanitarian can assist with student inspection of school lunchroom facilities and/or any other portion of the school environment, or demonstrate water or milk sampling, dish and food inspection procedures, or discuss sewage disposal, insect and rodent control, etc. The health officer, local physician, or the school, visiting, or public health nurse can help demonstrate immunization procedures, isolation and care of the sick at home, infant care, screening procedures, etc. Or they can help discuss community resources for those afflicted with chronic conditions, services to special groups such as mothers and infants, the handicapped, the aged, etc., or state, national, and world health problems and resources. Dentists or dental hygienists can demonstrate the topical application of sodium fluoride or discuss current studies in dentistry relating to enamel formation, dental caries, diseases of the soft tissues of the mouth, fluoridation, etc. Medical or laboratory technicians may be called upon to demonstrate simple diagnostic or research procedures, culture methods, current research, etc. Representatives of local voluntary health agencies are eager to help discuss the programs of their organizations.

*Surveys, records, and reports.* The list here is limited only by the ingenuity of the teacher and student. Wider use should be made of school health records to illustrate growth patterns, variations in height and weight by age groups, immunization level of the class, and similar topics.

Records of daily food intake; surveys of foods grown in home gardens or on farms in the area or enriched foods sold in local stores; or World Health Organization reports on malnutrition and related problems all can be used to add interest to studies of food and nutrition.

Surveys of sanitation in the school lunchroom, gymnasium, or elsewhere help illustrate concepts or uncover health problems needing attention.

Surveys or reports on the transmission of the common cold in a family, community or state regulations or communicable diseases and

New methods in research hastened the introduction of the Salk vaccine. Here the virologist examines tissue cultures of polio virus which have been removed from the incubator. The time required for isolation of polio virus was cut by one-fourth or more when tissue culture methods were made available to replace the use of live monkeys. Cost was reduced from thirty-five dollars to forty cents.

environmental sanitation, current research on health problems, World Health Organization priorities, research, the work of expert panels, advisory and technical services, and similar topics will help create and retain student interest.

*Selected References on Health and Disease*


American Association of School Administrators. *Health in Schools.* Twentieth Yearbook, Revised, 1951. Washington: The Association, 1951.

American Public Health Association. *Control of Communicable Diseases in Man.* N. Y.: The Association, 1955.

Anderson, Gaylord W. and Arnstein, Margaret G. *Communicable Disease Control.* N. Y.: Macmillan, 1953.

Faegre, Marion E. *The Adolescent in Your Family.* U. S. Department of Health, Education, and Welfare, Children's Bureau Publication No. 347. Washington: U. S. Government Printing Office, 1954.

Hanlon, John J. *Principles of Public Health Administration.* Second Edition. St. Louis: Mosby, 1955.

*Health Yearbook.* Stanford University, California: Stanford University Press, published annually.

Jay, Philip; Beeuwkes, Adelia M.; Blecha, Elmira E. and Bust, Marjorie S. *Dietary Program for the Control of Dental Caries.* Ann Arbor: Overbeck Company, 1951.

Joint Committee on Health Problems in Education, N.E.A. and A.M.A. *Health Education.* Fourth Revision. Washington: N.E.A., 1948.

Joint Committee on Health Problems in Education, N.E.A. and A.M.A. *School Health Services.* Washington: N.E.A., 1953.

National Health Council. *Health Careers Guidebook.* N. Y.: The Council, 1955.

New York State Department of Health. *Gift of Life.* Albany: The Department, 1951. (Available from Mental Health Materials' Center, 1790 Broadway, N. Y.)

*Public Affairs Pamphlets.* (Health Education Series) N. Y.. Public Affairs Committee, Inc.

Report of the National Committee on School Health Policies of the National Conference for Cooperation in Health Education. *Suggested School Health Policies: A Charter for School Health.* Chicago: American Medical Association, 1946.

Jersild, Arthur T. *Child Psychology.* Fourth Edition. N. Y.: Prentice-Hall, 1954.

Stackpole, Caroline E. and Leavell, Lutia C. *Laboratory Manual in Anatomy and Physiology.* N. Y.: Macmillan, n.d.


### Recorder's Report of Discussion on

# Health and Disease

Each discussion group responded in its own way and made its own contribution to the talk in which Dr. Bowman presented his idea of the ideal background of training in health education for the biology teacher. His paper was presented with the understanding that a teacher, so trained, can then select on the basis of community needs adequate course content from the area of Health and Disease.

Throughout the five groups there were threads of continuity in the discussion of Dr. Bowman's paper.

1.) Attention was called to the dangers presented by administrative and state requirements, which continually whittle down the time needed to study basic biology content.

2.) It was recommended that the planning of course content in health take into consideration the areas of interest and previous knowledge of the students.

3.) In school situations where health is handled as a separate course or in so-

cial studies or family relations, it falls to the lot of the biology teacher to stress and include in this course the *biological implications of* sanitation, diseases and health practices.

4.) It was recommended strongly that instruction in health emphasize positive attitudes and avoid establishing phobias and feelings of fright in the minds of the students. The possible danger of creating additional mental health problems in the minds of students was recognized, and discussion centered around ways this could be avoided.

5.) Biology teachers have the responsibility to develop in every student wholesome attitudes toward human reproduction as a natural process, that death is not evil but a part of the biological process of life, that saprophytes and parasites have a natural and important place in the organic cycle, and that decay of organic matter precedes physical build-up of other organisms.

6.) It is important in biology to develop in every student an understanding of the *relationship* that exists between sanitation and communicable disease control.

7.) It was recommended that in the biology classroom the emphasis in health be placed upon the basis of an understanding of the practice of health habits, and not on a description of medical practices and symptoms.

8.) It was stressed that it is very important to recognize that immunity to communicable disease comes about through human contact, as opposed to the erroneous point of view of living in an aseptic environment.

9.) Biology teachers have the responsibility to develop attitudes of acceptance of personal and community responsibility for health in order that as citizens in a community each adult can make intelligent decisions on health matters and controversial issues.

In planning content for a health course, all groups were concerned with the problem of student apathy toward the subject matter of health. This apathy was attributed to: (1) boredom due to constant repetition throughout elementary and high school; (2) lack of up-to-date health information in the background of the teacher, and an absence of recent materials for use in the classroom; (3) health practices being taught as moral values —"This is good for you," especially in the field of food and nutrition. Careful attention to level content and stratification as necessary in planning course content was recommended by all groups.

In the training background of any teacher today, there is need for an understanding of the growth and development of the personality of the child, along with an understanding of his physical growth. The biology classroom affords one of the finest opportunities for each student to gain personal satisfactions from his classwork when the teacher understands that the child's need for security is fundamental, and then accepts and respects the individuality of each student as a human being. In this situation the student's personality development progresses as attempts are made to help him meet his basic human needs. Then biology as a course can fulfill its goal of aiding the individual to adjust to his changing environment. With an understanding of the student's needs for security, discipline problems in the classroom become opportunities to help the child; classroom incidents reveal the child's needs instead of becoming occasions for punishment.

There was disagreement on the problem of including mental health practices in biology course content. Of those who considered this problem, two groups were agreed that it should be included, while one group dissented. All were agreed, however, that mental health procedures should be available to the teacher for conferences with emotionally disturbed students.

It was emphasized that the biology teacher is best prepared by training to give instruction in human reproduction as a natural process, particularly the study of the human reproductive organ systems and their functions. It is highly desirable that biology teachers examine their role in the teaching of human reproduction in relation to their school and to the community. To fulfill this role the bi-

ology teacher should represent one of the chief crystallizing influences in the educational system in imparting knowledge and the development of wholesome attitudes about human reproduction.

*Careers*: Discussion of careers in the field of health brought to the attention of biology teachers information on extensive opportunities which are open to professionally trained people with backgrounds in the biological sciences. (see National Health Council. *Health Careers Guidebook*. N. Y. The Council, 1955)

*Courses* for health teaching background training for the biology teacher should be broad, and 9 credits were considered as a minimum (1 credit being 1 hour per week for 15-16 weeks). This minimum background should be spread among the fields possibly as follows:

Anatomy and Physiology 3 credits
Human Growth and Development 3 credits
Personal and Community Health 3 credits

a) Communicable diseases
b) Chronic and non-communicable diseases
c) Organization, resources, facilities for health at local, state, national, and world levels

Enid A. Larson
Carmel High School
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*Recorder*

Discussion Group Part I with Behnke, Goodman, and Paulson as leaders.

# The Biology Teacher and Conservation of Natural Resources

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Natural resources ("land" in the economic sense) include everything provided by nature outside of man himself. Soil, water, minerals, plants, animals, and space are all actual or potential natural resources, irrespective of their present economic value.

Conservation of natural resources may be defined most concisely as "wise use." "Use" includes the handling of natural resources for any purpose, whether economic, scientific, aesthetic, or spiritual in character. Natural areas reserved for scientific study, national parks, and wilderness areas are used just as truly as is land from which agricultural, forest, forage and wildlife crops are harvested and from which minerals are extracted.

"Wise" use is that which most effectively promotes human welfare, with due consideration of the needs of the present and the future, the individual and the community. It requires sound judgment in determining the objectives to be sought and skillful management in attaining those objectives.

The interest of biologists in conservation as professional men lies largely, but not exclusively, in the application of biological techniques in resource management. Except for the training of specialists in the conservation field, any teacher who has a fraction of the knowledge agreed upon by the Southeastern Conference on Biology Teaching as essential for the biologist is adequately equipped to explain these techniques to students so far as basic principles are concerned.

The average teacher will, however, almost certainly need further knowledge of the practical application of these principles in the management of a particular piece of land. For example, if he is teaching in the Lake States, he should know not only the distinguishing characteristics of the genus Pinus and its place in the taxonomic hierarchy. He should also be able to recognize white pine, Norway pine, and jack pine in the field, and should know something of their longevity, rate of growth, soil and light requirements, and economic value. He should know not only that there are such things as plant and animal communities and plant and animal succession. He should also know the composition of the northern-hardwoods forest-type, the character istics and interrelations of its plant and animal life, its place in the ecological succession of the region, and its response to different methods of logging. In short, he should be able to show the student how basic science underlies applied science (or technology), which is the essence of natural-resource management.

In addition, he must acquaint the student with certain principles and practices that underlie all conservation practices. First and foremost is the necessity for complying with natural laws. Man does not "conquer" nature; he cooperates with her or he gets into trouble. This does not mean that he attempts to perpetuate conditions that would exist in the absence of any activities on his part. Nearly all land management involves a more or less drastic modification of those conditions. Agriculture, forestry, range management, wildlife management all aim at obtaining results that, for man's purposes, are better than those which nature would produce if left to herself. But unless his attempts to improve on nature obey nature's laws, he exhausts the fertility of the soil, causes ac-

A mountain meadow, forest, and Mount Adams on the Gifford Pinchot National Forest, Washington, illustrate multiple use for the production of sheep, wood, and recreation. U. S. Forest Service.

celerated erosion, increases the severity of floods, replaces valuable virgin forests with valueless second-growth, or exterminates some form of wildlife such as the passenger pigeon. In the case of renewable resources these laws are obviously biological laws.

A second basic principle is that of sustained yield. Briefly stated, this principle means simply that the resource must be so managed as to be continuously productive at some given rate. In the absence of man, there eventually develops a "balance of nature" or a "dynamic equilibrium," in which the interrelationships between the environment and the communities that occupy it remain relatively constant. Trees, grass, deer, and fish die and are replaced by others. When man steps in, he harvests these products whenever it best suits his purposes, and at the same time cooperates with nature to make sure that they are replaced promptly in at least equal, and preferably larger, quantity. In other words, he takes what he wants when he wants it, but in such a way as to use the productive capacity of the environment in obtaining bigger and better crops in a shorter time.

One of the tasks of the conservationist is to determine what that capacity is and how to attain it. Through research and experience we have learned that cultivation, fertilizing, and pest control produce larger agricultural crops; that planting, cleaning, and thinning increase the forest crop; and that providing a congenial habitat for fish and wildlife result in more trout and pheasants. Increased yields, harvested regularly and continuously, are a major objective of the land manager. He aims not only to have his cake and eat it too, but to have and eat several cakes where nature unaided might have given him only one.

Closely connected with the goal of larger yield is that of better quality. The resource manager seeks more nutritious food, straighter and cleaner-boled timber trees of desirable

species, whitefish and lake trout instead of sea lamprey, purer water, more attractive recreation areas. In both the quantitative and qualitative aspects of crop production, biological know-how, particularly in such fields as genetics, physiology, and ecology, is clearly an essential tool.

Much is heard these days of "multiple use" as a basic principle of resource management. Its objective is to produce a variety of goods and services from the same general area. A national forest, for example, may simultaneously produce wood, forage, wildlife, minerals, and recreation, and may help to check erosion and floods. The concept is an appealing one, but its application involves many difficulties, since some uses are partly or wholly incompatible with each other. A high degree of technical skill and sound judgment as to relative values are indispensable. Different methods must be used to produce the maximum amount of wood, forage, or game; we cannot have both primeval nature and a reservoir at Echo Park in the Dinosaur National Monument. The more products we try to get from the same area, the more difficult the task becomes and the more knowledge of biology we need.

All of this means that the biology teacher who is to be a conservation teacher must not only be well versed in the concepts and theories of the six areas of basic biology considered at the Southeastern Conference. He must also have a fairly intimate acquaintance with the application of these concepts and theories in the production and utilization of renewable organic resources such as agricultural crops, forest crops, forage crops, and wildlife crops. In order to do this, he must know how to take advantage of natural laws in producing a sustained yield of larger and better crops, and in combining the production of a variety of goods and services on the same area.

If, however, he is to treat conservation in any comprehensive way, he must in addition know something about the management of the non-crop resources of soil, which is partly organic and partly inorganic and in a sense renewable; of water, which is inorganic but not destroyed by use; and of minerals, which are both inorganic and non-renewable. Management of these resources constitutes an integral part of multiple use, and is usually inextricably interwoven with the management of crop resources. For instance, the way in which forest and range lands are handled has a distinct effect on soil erosion and the water supply. Mining may cause erosion and water pollution, and may interfere with forest and recreational values.

Another aspect of resource management is its dependence on the engineering sciences as well as the natural sciences. Surveying, the construction of roads, trails, irrigation works, and power plants, the use of machinery for the cultivation and harvesting of crops, and the processing of foods, lumber, pulp, and ores are all an important part of the picture. It is not to be expected that the biology teacher will stress the engineering aspects of conservation. He should, however, be aware of them since they are just as essential a part of the utilization of resources as are biological techniques.

Finally, the economic, social, and political facts of life are an item of major concern in the conservation of natural resources. Costs and returns—present and future, tangible and intangible, private and public—cannot be ignored. Management practices that do not produce a net income from the standpoint of society as a whole cannot be regarded as satisfactory, however perfect they may be from the purely technological point of view. Problems of policy involving such questions as public ownership of natural resources, and public cooperation with or control of private owners, loom large in the picture. Here again, no one expects biology teachers to function as economists, sociologists, or political scientists. Nevertheless they can and should point out the nature and significance of the factors that must be given consideration ontside of the biological field; and they should cooperate with teachers of geography and other social sciences in seeing that these factors receive adequate attention.

Conservation of natural resources is essentially the use in land management of sound technological practices to achieve certain desired economic and social ends. It rests on a

The Superior National Forest, Minnesota, produces deer as well as timber. U. S. Forest Service.

tripod, the legs of which are the biological sciences, the engineering sciences, and the social sciences. It is important that this broad aspect of the field be correlated with the biological concepts and theories which biology teachers will naturally stress.

The biologist who is an actual or prospective teacher of conservation has ample knowledge of basic biology for that purpose. In addition, he needs some training in the practical application of biological principles in the actual management of natural resources, and also information on the engineering and social aspects of conservation. Pre-service or in-service training to give him competence in these directions is highly desirable if not essential. It must not be overlooked that while biology is a science, land management is an art and a business which involves consideration of public policy as well as technique. Non-professional teachers of the subject obviously do not need professional training, but they do need a broad acquaintance with the increasing importance of natural resources in the national and world economy; with the nature of the problems involved in their wise use; and with some of the major principles and practices that can be used in the solution of those problems.

The biological aspects of conservation can best be taught outside of the classroom—on the farm, in the woods, at a logging operation, on lakes and streams, in parks and other recreational areas, on a national or state forest, at a water-softening or sewage-disposal plant, in a factory—in short, anywhere that natural resources are produced or used. Even a city street tree can be used to illustrate some of the basic principles of biology; and with a little imagination and some audio-visual aids these principles can be extended to the practices involved in the management of forest lands. Many lessons in conservation can also be drawn from objects in the classroom. A leaking water faucet can be used to point out both the difficulties in obtaining enough water of the desired quality when and where we want it, and the need for skillful management of forest and range resources on watershed lands. An ice cream cone can lead from the vanillin with which it is flavored, and which probably came from the spent sulphite liquor at a paper mill, to problems in forest management, the avoidance of waste, and the control of stream pollution.

It is particularly important that the student should acquire not only a knowledge of conservation objectives and practices but also an appreciation of his own responsibility in connection with natural resources. Being careful with fire, not picking rare plants, not being a litterbug, being thrifty in his use of materials of all sorts are examples of habits that should become automatic. Equally desirable is recognition of his privilege and duty as a voter in a democracy to support sound public policies of conservation.

Recent scientific progress in the conservation field has been slow and sure, rather than spectacular. Both basic and applied research

These seed trees left after a logging operation in loblolly pine in South Carolina will be removed after the new crop is well established. Kenneth P. Davis, University of Michigan.

are receiving steadily increasing support, with strong emphasis in biology on genetics, physiology, and ecology. Certain trends are significant. Among these are increasing popular acceptance of the goals of sustained yield and multiple use as general concepts but often without adequate recognition of the very real difficulties in attaining them. Closely connected with multiple use is the growing emphasis on the watershed as a natural unit of management, and on regional planning with the coordinated participation of federal, state, and private agencies.

Higher prices and improved technology are leading to the substitution of new materials and grades for those that are becoming scarce and expensive. Aspen in Michigan has changed from a weed tree to one of major value for the manufacture of paper pulp. The iron industry in the Upper Peninsula will probably be maintained by the substitution of low-grade for high-grade ore as the latter plays out. Most striking among the possibilities in this direction are the replacement of the fossil fuels by atomic energy and solar energy.

Steadily increasing pressure on natural resources throughout the world emphasizes the urgent need for conservation. This pressure comes from the population "explosion" and still more from the rising standards of living.

Abundant supplies of pure water go hand in hand with good forest management, as illustrated by this scene on the Chelan National Forest, Washington. U. S. Forest Service.

More and more, the rate at which we use materials and energy increases faster than does the population. Twice as many people may demand several times as many goods and services. This fact will become more obvious and more significant as the underdeveloped countries are industrialized.

Because of man's conquest of time and distance, today we live physically if not ideologically in one world. The interdependence to which we have long been accustomed among the States of the Union is fast developing among the countries of the world. Wheat in the United States, iron in Labrador, cattle in Argentina, oil in Iran, tin in Malaya, rice in China, play a significant part not only in local but in world affairs. The basic problem involved in the conservation of natural resources everywhere is how to use finite resources so as to meet the needs of an indefinitely large population at an indefinitely high standard of living. That biology has an important part to play in its solution no one can doubt.

Dean Dana leads a field trip on forestry and land use.

### Recorder's Report of Discussion on

# Conservation

The body of concepts known today as Conservation probably cannot be classified as a science—but rather is related to biology in the same way as practical medicine, in that both are applications of biology.

Emphasis should be placed on the fact that conservation in practice is *wise use*. It is basically land management, founded on scientific principles, for man's economic and social purposes. Because of the basic importance of natural resources, public participation in conservation programs is essential. This participation may take the form of cooperation, control, or ownership.

The following should be among the results of effective conservation teaching. The student should be led to possess:

1.) An appreciation of why natural resources are so important that their conservation is imperative.

2.) An understanding of the possibilities of producing more and better crops by modifying natural conditions in accordance with natural laws, and of such basic principles as sustained yield, multiple use, and the substitution of one material for another.

3.) An attitude of carefulness, respect and thrift in his own contacts with natural resources and his use of their products.

4.) Recognition of his responsibility as a citizen for the adoption of sound public policies, and the consequent necessity of being sufficiently informed to vote intelligently on conservational matters.

5.) A familiarity with nature that will enable him to live a fuller, richer, and more satisfactory life.

*Conservation Attitudes*

In regard to the development of conservation attitudes, there was general agreement that this could most effectively be done at the elementary school level. (A number of techniques were mentioned by our elementary school participants.) Probably the scope and sequence of experiences, materials, and methods for implementation would best be on the developmental or "horizon" basis—from the home, where the learner begins, outward to city, state, and world. Camping may provide opportunities for developing these desirable attitudes. With a good nature and conservation centered program, planned to tie in with and enrich the school curriculum, we can create a desirable background and lay the strongest foundations of conservation educa-

tion. Conservation teaching at these levels can be simple, without oversimplifying, and still be effective. The teacher need not be an expert or highly trained in all areas of conservation to instill and teach youngsters many of the conservation ideas. (Someone in a group suggested, "It is not a lack of courses that causes poor teachers—it is poor teaching in the courses they already took.") The teacher's attitude can be, and is, caught by the student even though the teacher is not highly trained and a specialist. Here, probably more is "caught" than "taught" in achieving our purposes. Teachers are often reluctant to go out on field trips, or to camp, largely from fear of not knowing all about what may develop. The teacher should try to be a participant with the group, learning with them in a discovering, exploratory atmosphere, and not afraid to lose status as the ever ready expert.

*High School Teaching*

Relation between biology and conservation should be emphasized throughout the biology course, with a summary and integrating unit near the end of the course. The economical, political, and social aspects should be made clear. It is assumed that conservation will also be included in courses in geography and the social studies. In addition to these approaches, a separate course in conservation may or may not be desirable, depending on local circumstances. It is recognized that geography and the social studies as well as biology have an important part to play in conservation education and that cooperation between teachers in these fields is highly important.

As much field work as possible is desired in relating biology to conservation. When longer trips are impossible, much can be learned from city street trees, playgrounds, parks, industrial plants, etc. Objects in the classroom and school can be related back to the resources from which they came—locations, abundance or scarcity, problems involved in their conservation, etc. Week-end or Saturday and Sunday field trips are possible. One can train a few good people: a club, or some of the most interested students; they will then assist in leadership capacity, and help the teacher. Parents will help: good public relations will follow. Utilize the leadership of local garden clubs, advanced Scouts, nature and conservation groups. Each have conservation activities and committees, and may conduct regular field trips.

*Teacher Training Programs*

A separate course in Conservation of Natural Resources and/or Conservation Workshop should be available, with prospective teachers in the biological and social studies urged to elect it. (Many thought such a course should be required.) A good teacher, with the ability to inspire as well as to inform, is essential.

Two discussion groups, in particular, brought out the point that it takes more than four years to "train" a good biology and conservation teacher. (Some pointed out that the process was still continuing after twenty years.) In his efforts to better know the local flora and fauna, the ecological descriptions of the area, and otherwise keep abreast, field work with local nature groups is also most valuable to the teacher. Attendance at Audubon and other summer camps for the training of conservation leaders, workshops of the same sort, etc., are possibilities.

Many felt that the workshop method of learning is far superior to the traditionally over-pre-structured class in that it is a more integrative experience. For the student need not concern himself with a lot of reorganization, since he gets methodology as well as subject matter, and factual information at the same time.

Building of attitudes is important at the college level also, but when attitudes are to find expression in action, they must be backed up by facts. Both teachers and students should recognize that the objectives and basic principles of conservation are relatively simple, but that the techniques of management may be very complex. Career opportunities should be explored, and the necessary preparation for these indicated.

*Techniques and Methods for Implementation*

Specific examples of techniques and methods suggested to implement the subject matter in conservation education as presented by Dean Dana are:

Conservation field days and fairs
Conservation, science, or biology clubs
Experiments and demonstrations--in and out-of-doors
Special units; group work experiences
Use of research in projects, and classroom exhibits
Wise use of audio-visual materials (encourage students to evaluate these)
Live plants and animals
Landscaping program for school grounds
School gardens; school or community forests
Field trips; nature trails; nature centers
School camping—pre, at, and post-camp activities and projects.

It may be difficult at present to evaluate all of the intangible returns from the investment we need to make in a good conservation education program. However, the spiritual and aesthetic enjoyments one may experience are among the most effective, valuable, and lasting dividends accruing from wise resource-use.

Rex Conyers, Senior High School
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*Recorder*

# Summary of the Scientists' Contributions

CHESTER A. LAWSON
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The initial sessions of the North Central Conference on Biology Teaching were concerned with the relation of fundamental biology to applied biology in the training of high school teachers. Specialists from the applied areas of (1) Plants and Man, (2) Man's Food Supply, (3) Health and Disease, (4) Conservation, and (5) Human Genetics served as consultants and presented their views concerning the kind of training needed to produce qualified biology teachers. The participants of the conference were divided into five groups, with each consultant presenting a paper on his subject to each group. This was followed by group discussion directed at two objectives. The first was an elaboration, evaluation, and supplementation of the consultant's contribution. The second was a determination of practical ways of effectively implementing in the classroom the recommendations of the consultant.

A distillation of the specialist's papers produced a list of essential elements recommended in the training of biology teachers. Some of these elements may be classified as objectives and others as means of attaining objectives.

The conclusion must not be made that the following list of objectives was exhaustive, nor that it was subscribed to by all consultants:

1.) "A clear concept of man's position in the community of living things and his relation to environment." The intended consequence of this concept was a proper humility concerning man's position in nature.
2.) "To give students certain fundamental facts and induce in them certain habits and attitudes of thought and certain interests which will form the basic stock-in-trade of would-be teachers."
3.) "An understanding of the relationship between the pure sciences, and the applied sciences; that the applications of science are, in the final analysis, the extensions of pure science discoveries to immediate human problems; discoveries made by men who have sought to explain the phenomena and the objects which surround them, and who have not been directly attempting to invent light bulbs, antibiotics, weed-killers, and atomic bombs."
4.) To produce broadly educated persons rather than narrow specialists.

5.) A teacher who has imagination, inventiveness, the ability to reorganize biological information into new patterns, and to pursue up-to-the-minute knowledge as it becomes available in new books and in current scientific journals.

In addition to the broad objectives listed above, each consultant stated or implied that prospective teachers should be familiar with the particular applied field that the specialist represented.

To produce a well-trained teacher, experience in the following areas of biological knowledge was recommended. It was not intended that each area mentioned should constitute a course, nor that some of the areas could not be incorporated as parts of others. The list included: biology as an integrated course, botany, zoology, classification, systematics, comparative morphology, plant physiology, evolution, genetics, ecology, bacteriology, entomology, physiology, human anatomy, human reproduction, human growth and development, embryology, and growth and development of plants.

Courses in related areas were recommended. They were: geography, conservation, physical sciences, biochemistry, horticulture, anthropology, hygiene, psychology, and statistics.

The conference was cautioned that narrow specialists should not be produced. To prevent this, courses in the humanities and social studies should not be neglected. But this is not all. "The teacher must, if he is to be a wise and percipient teacher, build upon the foundation of facts and attitudes which he has acquired as an undergraduate student. This post-college growth may develop in several ways: through membership in biological organizations and attendance at their meetings, through a definite program of reading new biological books and biological periodicals, through travel, through a continuing interest in fields such as anthropology, sociology, and geography, and through occasional college refresher courses in the biological sciences."

Each consultant made further recommendations concerning knowledge necessary for teaching aspects of his specialty to high school students.

The consultant for "Plants and Man" recommended that high school teachers be familiar with (1) the significance of the domestication of plants and animals for the early development of human culture, and (2) the energy relations among the sun, green plants, man and other animals, and bacteria and fungi.

An understanding of the relation of biology to man's food supply is essential for any biology teacher. "The provision of adequate supplies of food for the earth's rapidly increasing human population is one of the major problems of biology. Failure to solve this problem and to provide adequate food-increases will doubtless lead to further demand for *Lebensraum* and will inevitably produce grave international crises of a social, political, and military nature."

Biological investigations aimed at increasing the world's food supply were reported to be in the following areas:

1.) The development of crop varieties of superior yield-capacity through plant breeding and selection
2.) The development of animal varieties of superior yield-capacity through breeding, selection, and improved animal feeding
3.) Weed control
4.) Insect control
5.) Plant disease control
6.) Increased knowledge of plant nutrition and soil structure and behavior
7.) Introduction of new crops
8.) Conversion of arid lands into agricultural areas
9.) Improved soil conservation methods
10.) Increased utilization of food products from lower plants
11.) Developments in the study of photosynthesis
12.) Changing social and religious attitudes to permit available foods to be eaten that are prohibited by social and religious taboos.

The promotion of health and the discouragement of disease are laudable human objectives that can be realized largely through the application of biology. The consultant on "Health and Disease" recommended that instruction in this area should include:

1.) Growth and development of the individual in the areas of physical, mental, and emotional health
2.) Anatomy and physiology
3.) General understanding of communicable diseases
4.) A knowledge of chronic diseases
5.) An understanding of the organization of health resources in the community, the state, the nation, and the world.

Because of the high standard of living and the habits of waste practiced by our culture future generations may inherit a destitute and ravished earth. To forstall this possibility, instruction in conservation and the development of new attitudes toward the use of natural resources are essential.

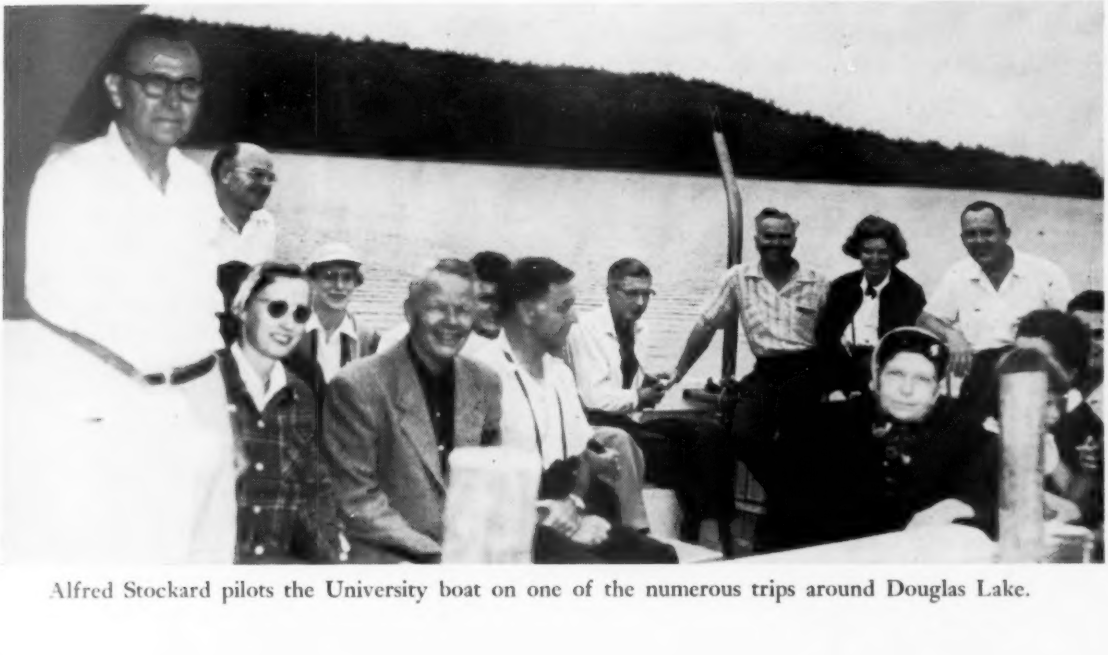
The consultant on Conservation recommended that such instruction should include an understanding of:

1.) The necessity for man to comply with natural laws
2.) The principle of sustained yield
3.) The production of better quality in natural products
4.) The principle of multiple use
5.) The management of water, soil, and mineral resources
6.) The relation of engineering to conservation
7.) The economic, social, and political aspects of conservation.

Knowledge of genetics may be of immediate personal concern to man, or it may be of general social concern. The prospective parent faced with the probability of producing abnormal, handicapped children needs the advice of the human geneticist, and the socially minded citizen needs to know the possible consequences of indifference to the genetic potentialities and inadequacies of human populations and of disregard for the possible genetic effects of atomic radiation.

To prepare a citizenry capable of understanding the relation of genetics to human welfare the consultant recommended that high school teachers have knowledge of a minimal core which would include the mastery of such topics as Mendel's laws, polygenic inheritance, multiple alleles, autosomal and sex-linkage, mutations, the nature of gene action and genic interactions, and the relating of the foregoing to the structure and behavior of chromosomes.

In addition, the teacher should be acquainted with the unique problems in human heredity resulting from human habits of reproduction and the impossibility of performing breeding experiments. In order to understand how the geneticist circumvents these difficulties the teacher should have a knowledge of statistics, population genetics and the theory and practice of determining the heritability of human traits.



Alfred Stockard pilots the University boat on one of the numerous trips around Douglas Lake.

# PART II Recommendations on the Problems of Teaching Biology

I. High School — III. Teacher Training
II. College — IV. State Department

LEADERS FOR PART II

*First Row* (left to right): Chairmen Richard Wareham, John Breukelman, Howard Phillips, and Arthur Baker.
*Second Row:* Recorders Frances Hall, Robert Smith, Stanley Mulaik and Dorothy Matala.

I. *High school Biology*

A. How shall we meet the needs of the individual student—his capabilities, interests and potentialities?

BACKGROUND: Students should have educational opportunities commensurate with their abilities and objectives. Special courses and programs for particular groups may be useful in teaching them more effectively. Local conditions, such as school size and staff, community relationships and the like, influence what can be done to insure that biology will give something of value to the study by students of all levels of ability.

We need particularly to find a way to develop more fully the capabilities of gifted students, especially their powers of analysis and synthesis. The misconception that equality of opportunity in our democratic system of education demands identical or uniform achievement has too often resulted in pulling the gifted student down to the level of the average, to the detriment of both the student and the development of leadership for the nation.

Currently, available evidence indicates that the ability to become a scientist is not a single nor a specific and identifiable human trait but is correlated with high level ability in general, perseverance, creative imagination and interest. Interest often develops early in the grades and high school experiences are particularly important in focusing interest on science. Sound and stimulating science teaching from the elementary grades through senior high school is thus essential to recruitment and education of future scientists.

RECOMMENDATIONS:

1. There should be a year of biology in the ninth grade or preferably in the tenth grade, and use should be made of relevant extra-curricular community and organizational activities at all levels.
2. This general biology course should be designed for all students.
3. Teachers should recognize individual differences among the pupils, in ability, preparation, and background. They should make a reasonable effort also to identify similarities.
4. Teachers should provide a variety of materials and assignments to give full scope to individual differences.
5. Capable students interested in science should have opportunities to become acquainted with working scientists by obtaining their assistance on special projects, tours of scientific institutions, short intensive courses in special topics given for them in colleges, universities, research institutes and field stations, and summer apprenticeship programs.
6. Students interested in biology should be encouraged to take mathematics, chemistry and physics in high school, along with biology and work in other major areas. The school should make such a program available. Moreover, the students interested in biology should have an opportunity to develop through individualized work or advanced courses, with credit, in the junior and senior years.
7. A possible approach to the general biology course would include student cooperation with teacher guidance of individual and group projects, the use of individual, school and community resources in establishing the objectives of the course, and an evaluation scheme for the *total* performance of the individual.

B. How can we teach scientific methods and develop scientific attitudes?

BACKGROUND: One of the primary objectives of the high school course in biology is to develop scientific attitudes in students. This can be done best when the student understands how the methods of the sciences differ from those of the non-sciences. Therefore, the teacher should be informed on the problem of the nature and meaning of science and the methods of science. Scientific methods are difficult to define, but the following suggestions may prove helpful.

1. Natural science is a body of organized knowledge which consists of assumptions, reproducible observations, testable hypotheses, and principles pertaining to relatable phenomena in nature.
2. It is incorrect to speak of *the* scientific method. There are many methods in science.
3. A distinction should be made between the creation of science through research and the application or use of science as in medicine, conservation, and engineering.
4. The methods of science and the techniques of science are not synonymous.
5. Although the methods of science have broad application, they cannot be applied universally.

RECOMMENDATIONS: The Conference recommended that biology instruction be so directed that it will develop in high school students scientific methods, approaches, and attitudes through any, all, or any combination of the following devices:

1. By showing students that the methods used in in the biological and physical sciences need not necessarily be confined to these areas.
2. By the example of the teacher who, himself, uses the methods, approaches, and attitudes of scientists.
3. By reference to the classics of science and the manner in which scientists attacked their problems.
4. By providing opportunities in class or clubs for experiences in using scientific methods in securing answers to questions raised, in minds of students, by skillful teaching.
5. By relating, throughout the course,

the subject matter of biology to the methods of science.

6. By recognizing that a test of effective teaching in this area is the ability of the student to apply scientific attitudes to his daily problems.
7. By field study of zonation and succession in various ecological habitats.
8. The opportunity should be provided to study world-wide science and to see that science is a product for all races and nations.
9. By carrying on long-time projects involving a problem studied by successive classes over a period of years.

C. What are the interrelationships between biology and the other areas and levels of the total school curriculum?

BACKGROUND: Continued expansion of science instruction in the elementary school can have profound impact in the development of a citizenry equipped to live in a world increasingly influenced by the growth of scientific knowledge. This opportunity can be fully realized, however, only by considering science instruction from the first grade to the twelfth as a continuing experience; each succeeding step should build upon what went before. This means that many topics traditionally included in, for example, ninth-grade general science, may be taught and taught well in preceding grades, thus leaving a place in the ninth grade for inclusion of material from the usual tenth-grade biology course. All this can be done *only* by continuing consultation and planning by all those concerned with the science curriculum—elementary and secondary teachers, administrative staffs, consultants, reputable scientists. Biological material can be taught at any level.

RECOMMENDATIONS:

1. Elementary and secondary science programs should be planned jointly by elementary and secondary teachers, aided by administrative staffs and scientists.
2. The high school teacher should serve as a resource person for the elementary school. For example, the secondary teacher may invite elementary pupils and their teachers to participate in special events such as project nights and science fairs; can provide or lend supplies and equipment; help design demonstrations and experiments; aid in maintaining living materials; identify plants and animals.
3. The tenth grade is a desirable level for a full biology course, to be complemented by continuing opportunities for study in the field in the later high school years.
4. In order that biology may be integrated into the total secondary school program and into the lives of high school students the Conference recommended:
   a. That biology teachers have a general knowledge of other areas and that other teachers have a general knowledge of biology.
   b. That situations be created which will encourage individual, small group, and class projects to culminate in assembly programs and other school activities. These projects may be extended into intra-school and inter-school fairs, Junior Academy of Science exhibits, and similar activities.
   c. That inter-departmental planning be encouraged.
   d. That students be given an opportunity to apply in other classes what they have learned in biology. Illustrative of the ways in which biology may be integrated with other secondary school subjects are the following:
      (1) Use biological information in English themes.
      (2) Use biological data in formulating curves and graphs in mathematics courses.
      (3) Evaluate health problems, natural resources, and agricultural productivity in social science courses.
      (4) Study the derivation of biological terms in language courses.

Discussion Group formulating recommendations in Part II of the Conference.

(5) Speak on biological topics in speech classes.
(6) Use plant and animal forms and patterns of structure in art work.
(7) Use the facts of human reproduction, in relation to family life and social living.
(8) Use knowledge of human physiology in physical education.
(9) Apply in home economics classes knowledge of biology concerning the selection, care, and use of foods.

D. How can current scientific developments and social trends influence the content of biology courses?

RECOMMENDATIONS:

1. The high school teacher may keep up with research developments in his field by some of the following means:
   a. Local meetings, near enough to the teacher's community to reduce travel and expense to a minimum, are one of the best means. Such meetings should include scientists, people experimenting in the teaching of biology, specialists in education, administrators and teachers. The NABT may well take the lead in organizing regional, state and local meetings of this character.
   b. Science days at colleges and universities provide an opportunity to see research in progress and learn about new developments.
   c. Short conferences and institutes of several weeks are excellent means both for studying biology under the tutelage of leading biologists and for the development of new approaches to teaching.
   d. Regional and national meetings of professional groups provide excellent opportunities; local industrial and scientific groups may provide travel grants to enable teachers to attend such meetings.
   e. Summer opportunities to work in research institutes, industry, colleges and universities, agricultural field stations and other centers of biological investigation are excellent means for enabling the teacher to learn more about an area, gain access to good libraries, participate in research, and contribute manpower to science through nonteaching activities.
   f. Teachers should arrange sessions

with their students for joint discussion and review of reading technical, semi-popular and popular journals.

There are numerous periodical publications that may be useful to teachers and students. It is impossible to provide a complete list here, but the following are among those that may be of value in high school biology and may be available in the average high school library. *American Biology Teacher, Audubon Magazine, Canadian Nature, Cornell Rural School leaflet, Junior Natural History, National Geographic, Natural History, Nature Magazine, School Science and Mathematics, Science Education, Scientific American, Scientific Monthly, The Science Teacher.*

Other publications (many of them free) are available from governmental agencies, special interest groups, and private corporations.

g. Appropriate organizations should be encouraged to develop a publication for high school teachers, incorporating references, short articles on latest developments, review articles, and regional sharing of ideas.

2. Increasing urbanization has profound implications for high school biology teaching.

   Urbanization creates a problem and an opportunity for the biology teacher. One answer is to bring nature to the city youth. This can be done by exploring the flora and fauna of the city through living exhibits, including domestic species, in museums, zoos and botanical gardens, and through field trips making effective use of parks, vacant lots, lawns and gardens, streams and lakes. Of course, trips to the country are also recommended.

3. Recent social and scientific events have made it necessary to change traditional content.

   These events influence the degree of emphasis to be given to certain topics and principles, and the examples selected for illustrating principles. Both in the interest of accurately reflecting the accumulated body of knowledge and of showing students its significance in their own lives, teachers must carefully evaluate topics to be included. For example, population genetics and biophysics, disciplines with important implications, were virtually unknown to the designers of high school courses forty years ago.

4. High schools have been sharply criticized for anti-intellectualism and watered-down content. Some promising ways of upgrading instruction are as follows:

   a. As elementary science develops, plan high high school courses to build upon student knowledge.

   b. Develop mathematics programs which stress understanding of mathematical concepts and ways of looking into phenomena and relationships, rather than skill in mere manipulative operations. Given such mathematical background, students can be given much more rigorous science courses and thereby be prepared for work in and understanding of contemporary scientific endeavor.

E. What methods of instruction give promise of improved learning?

BACKGROUND:

Experience has demonstrated the necessity for the use of many methods and techniques in the teaching of biology. It should be emphasized that the success of any method is directly dependent upon the teacher and the total environment of the learner. The teacher should be familiar with many methods in order to select wisely the proper method to fit best the situation. For instance, in a discussion of texts and their use, it is assumed that the teacher should use any text as a teaching tool, a source of information, and not as the set course of study. With the active cooperation of the administration the teacher with insight will find ample op-

portunity to exercise initiative and plan wisely.

RECOMMENDATIONS:

1. A wider variety of community and natural resources should be used.
   a. The school should work with various other agencies for the development of outdoor classrooms, school forests, school camping sites, etc.
   sites, etc. Students should aid in planning and planting of all such areas. Local planning boards should always be consulted. This may be accomplished by cooperating with park boards in planning and maintaining the school campus.
   b. Better field trip implementation through:
      1.) Multiple subject use of field trips.
      2.) Careful planning with a pre-trip look at what is to be done and why, detailed instruction sheets for the trip, and a review of post-trip results.
      3.) Use of out-of-school hours for field trips where possible.
   c. Compilation of a catalog of available local scientific resource personnel and local resource places. In use such a catalog is kept current and annotated so that it becomes a cumulative record, incorporating the experience of many teachers. The group encourages the use of technical and college resource people for assistance in the high school biology program. Student appointments with resource persons should be arranged with the approval and advice of the science teacher.

   In competitive situations the strictest ethics must be observed. We deplore the condition where the teacher does the work and the student gets the credit, or the opposite situation.
2. The judicious use of audio-visual aids enhances teaching. Biology teachers should have facilities for:
   a. A motion picture projector, so that suitable films can be used.
   b. Microprojection, to help in teaching when microscopic organisms, tissues, etc., are under consideration.
   c. Opaque projection, in order to make wider use of drawings, photographs, etc., not in the textbook. Images of specimens may also be projected.

   Teachers also may successfully use such devices as "Vue-Master" reels, 3-dimension photographs, tape recordings, records of bird songs, quiz boards, television, and radio in addition to the usual models, charts, blackboard and chalk, and microscopes.
3. Suggestions:
   a. To the teacher:

   A multi-text system or classroom library is usually preferable to a single text. This discourages the use of the text as the prescribed course of study; encourages comparison of statements by different authors; may aid in developing critical thinking; may encourage a greater variation in the types of teaching activities.

   The teacher's manuals prepared to accompany the text should be known and used by the teacher to become familiar with the philosophy and frame of reference. Additional supplementary teacher aids are available from publishers, supply houses, etc. and should find wider use.
   b. To NABT:

   NABT might serve as a clearing-house for suggestions by teachers about textbooks—what should be included, how intensive or extensive, types of pictures, vocabulary, etc. Authors and editors might find this service useful.

   A committee of NABT might prepare reviews of texts in which the circumstances under which the

book would be useful are indicated.

4. Individual and group project work directed toward increasing intellectual growth and manipulative skills of the participants is recommended.
5. We recommend that school budgets include provision for purchase of desirable materials and apparatus necessary for good teaching procedure. However, an imaginative teacher may only partially compensate for low budgets by: enlisting student and school shop aid in constructing apparatus, animal cages, etc.; using inexpensive houseware items; and by collecting live material locally. Often student participation in these activities constitutes a valuable learning experience and leads to a vocation or avocation.

F. What should administration contribute to teaching of biology as to: reasonable class size, academic freedom, freedom from interruption, helping the beginning teacher, financial support, in-service education?

BACKGROUND:

Among the many responsibilities confronting the administration of educational programs in biology that require urgent attention are: a definition of the reasonable size of classes and laboratory sections, adequate facilities for classroom and laboratories, provision for field studies and outdoor laboratories, adequate financial support for all facets of the program, and an increased freeing of the teacher's time. Since this list of problems represents a small portion of the total number, and because of their complex nature, administrators obviously need the best advice available relative to the problems. Emphasis should be placed, however, on the proper recognition and a mutual understanding of the problems when advice is made available.

RECOMMENDATIONS:

1. Teachers and scientists should take the initiative in properly and adequately informing administrators in regard to the needs of the teachers and scientists. Since it is necessary for administrators to understand clearly the reasons underlying requests for financial and other aids to support requests for adequate space, materials, etc., all attempts at solutions should involve the best cooperative thinking of all groups in order to provide a program that will lead to more effective educational experiences for the pupils.
2. Efforts should be instituted at the national, state, and local levels to acquaint administrators with the objectives, values, and problems in science teaching. Some specific suggestions are:
   a. Teacher loads should be determined primarily on the basis of contact hours with students.
   b. Numerous assignments, particularly those not closely related to the educational program, should be reduced and unnecessary time consuming procedures should be eliminated.
   c. Twenty-four students per class is considered desirable, although available equipment, room sizes, and local conditions determine to a great extent reasonable class sizes.
   d. Specific attention should be given to the consideration of these problems at future conferences, institutes, etc.
3. Students who show an inclination to carry out investigations should be encouraged to do so and school facilities should be made available for such investigations.

G. How can teachers of biology find out what other science teachers are doing? How can organizations and publications serve the biology teachers?

RECOMMENDATIONS:

1. The high school biology teacher can find out what other teachers are doing by:
   a. Active participation in local, state, and national organizations of scientists and/or teachers.

Discussions continue between sessions—Osborne, Mouser, Brother Charles, Webster, Keene, McNelly, and Armacost.

b. Visiting other schools with a substitute hired during his absence.
c. Reading of publications dealing with science teaching—not biology alone.
d. Encouraging his students to participate in such activities as science fairs and talent search programs.
e. The NABT is urged to take responsibility for developing a national pattern of local (regional) meetings for biology teachers.

2. Organizations and publications can serve the biology teacher by:
   a. Reporting successful activities of other science teachers.
   b. Reviewing new books in the field. field.

H. What types of teacher recognition programs have merit?

RECOMMENDATIONS:

1. A good teacher recognition program should incorporate the following features:
   a. It should not antagonize the teaching personnel in the school.
   b. Arise from sources outside the school.
   c. Encourage all teachers to do a better piece of work, or render a greater service.
   d. Encourage more students to become teachers.
   e. Impress upon the public the importance of the teaching profession.
   f. Provide recognition by scientists of the importance of teachers.
2. Criteria for selection should be carefully chosen.
3. The method of selection should include a variety of judgments (colleagues, administration, students, community, former students).

I. How can the classrooms be made more efficient with the available space, time, and resources?

BACKGROUND:

Insofar as possible and practicable all high school science classrooms should be used exclusively for science classes. If,

in emergencies, the room must be used for other purposes, classes should be scheduled which will neither disturb experiments in progress nor require the putting away of equipment which will have to be used again a short time later.

When remodeling old school buildings or constructing new ones consideration should be given to the special space needs related to the teaching of secondary school biology. Careful planning is required. *School Facilities for Science Instruction*, distributed by the National Science Teachers Association, 1201 Sixteenth St. N.W., Washington 6, D. C., and the *American School and University Year Book*, 1954-55, published by School Executive, New York City, are recommended. The report of the Southeastern Conference is also pertinent on this point.

RECOMMENDATIONS:

1. That biology teachers, science supervisors, citizens, and if necessary, out-of-town and/or out-of-state specialists assist the architects in planning the biology (science) rooms.
2. That the following principle be incorporated into the plans for the biology (science) rooms.
   a. Plan multi-purpose rooms instead of separate lecture and laboratory rooms, equipped to accommodate no more than 25 students.
   b. Remember that multi-purpose science rooms must be larger than ordinary classrooms.
   c. Provide for flexibility in room use.
   d. Install fixed furniture around the walls of the rooms with movable furniture in the center.
   e. Provide for the rooms to be darkened when audio-visual aids are being used.
   f. Provide accessory rooms which may be used for storage, projects, and the like.
   g. Plan for the biology rooms to be on the first floor of the the building.
   h. Provide space for experimental work and for the growth and care of plants and animals.
3. Time should be provided for the biology teacher to have a preparation period in order to collect and care for living materials in their classrooms, set up demonstrations and plan the work for laboratory assistants if they are available.

II. *College Programs*

A. In what ways can the teaching of college biology be improved?

BACKGROUND:

A great amount of attention is being centered by numerous committees, conferences, institutes, societies, and other groups on the need for the improvement of the teaching of biology. The magnitude of the attention focused on this problem, particularly at the college level, is indicative of the urgent necessity for improvement. There is a tremendous waste in these efforts, however, especially in regard to repetition and duplication, which comes about as a result of a lack of coordination and integration of the activities, decisions, and recommendations of the many groups. The need for making the worth-while contribution from the various groups available to biology teachers, researchers, and administrators poses a significant problem for future consideration.

RECOMMENDATIONS:

1. Excellence in teaching, although difficult to measure readily, should be used at the college level as one of the bases for professional advancement.
2. The teaching of introductory biology students should be considered a great privilege and an opportunity for the good teacher. The assignment or appointment should have the prestige appropriate and equivalent to that of any position in the college.
3. The necessity for properly training graduate students and for using them as assistants in college courses is recognized. In introductory courses graduate assistants who select teaching as a career should work, however, as apprentices directly under the supervision of the professor, and insofar as possible with him. Moreover, grad-

uate students who are prospective teachers, should be required to serve as teaching assistants.

4. The beginning courses in biology should be taught by those department members who are richest in experience, most enthusiastic about their subject, most effective in exposition, and most interested in students. These individuals should also have an understanding and sympathetic and cordial relations with other disciplines and departments.
5. The college teacher should make systematic observations on science classes in elementary schools, high schools, and other colleges, including teacher education. His observations should be used to translate properly the educational requirements of the students at all levels and to communicate these needs to the people responsible for educational programs.
6. Sabbatical leaves for study and/or travel or special assignments should be provided with subsidy. Regular sabbatical leaves or short leaves should be utilized by teachers, when appropriate, to engage in field studies.
7. Regularly scheduled meetings of college teachers should be held, not only within departments, but also on an inter-divisional or inter-school basis, for discussion of instructional objectives, curriculum organization, course content, teaching methods, provisions for various student groups and similar problems.
8. Teachers should be encouraged to organize and attend summer institutes and conferences for college teachers in biology.
9. Teachers should be urged to operate a continuing program of self-evaluation.
10. In the preparation of college teachers emphasis should be placed on the importance of providing a seminar or practicum on educational philosophies, teaching methods, and the problems confronting the college teachers.
11. Great care should be exercised in the selection of college teachers. Once selected, a continuous program of improvement, including remedial measures, should be required.
12. Strong and concentrated effort should be made to develop film and television programs to complement "live" teaching as well as for popular consumption. Through this medium, high quality lectures and demonstrations can be made available to all students. The instructor would then have more time and greater energy to devote to discussion, tutorial, and laboratory instruction on a student-teacher contact basis.
13. Biological research, both directly and indirectly, contributes to the improvement of teaching. It develops the competence and enthusiasm of the staff and provides a stimulus for students brought into contact with the advancing frontier of the biological sciences. All programs which encourage the proper interrelationships and relevancies of research to biology should be encouraged.
14. More of the individual teacher's time can be directed toward teaching, if the number and variety of college courses can be reduced. It is urged that administrators and teachers closely scrutinize biological curricula in an attempt to reduce the number of courses, but at the same time, increase their quality.

B. What types of advanced training (graduate training) for biology teachers can or should the colleges provide?

RECOMMENDATIONS:

The Conference recommended:

1. That the science consultants or supervisors should have the following qualifications:
   a. Ability to get along with people.
   b. At least a master's degree with study at the graduate level in both science and education.
   c. Science teaching experience in a variety of schools, some of it recent.

d. Substantial training in science (biological, physical, and earth sciences).

2. That the taking of desirable courses by the teachers be facilitated by the scheduling of such courses in cycles so that the teacher can make long range plans.
3. That colleges should offer a wider variety of courses designed for inservice teachers during summer sessions. If a course is unavailable at the institution, students should be permitted without penalty to go elsewhere for it.
4. That field experience, preferably at a biological station, be required.
5. That courses be designed which bear directly on teaching problems, yet offer opportunities for reviewing and emphasizing basic knowledge; e.g., Biology of the Urban Environment, Recent Advances in Biological Sciences.
6. That colleges provide courses at the graduate level which are introductory in nature to fill gaps in the teachers' previous preparation. These should not be undergraduate classes, but for graduate students, and taught by a member of the graduate faculty.
7. That colleges make available facilities and materials to encourage under qualified direction, special investigations by high school teachers.
8. That academic, industrial, and governmental research laboratories hire biology teachers as summer employees.
9. That colleges should provide liberal library privileges to all teachers in their areas.
10. That programs for advanced training of teachers be set up in subject matter departments with complete inter-departmental cooperation. Such programs should be recognized by educational authorities for meeting advancement qualifications. This need not necessarily lead to the present master's degree.

III. *Teacher Education*

A. What constitutes a desirable program for the preparation of a prospective biology teacher? How can teachers be prepared for the wide spread of topics or courses they will be required to teach? Is there a need for a senior integrating biology course? Should the college biology program attempt any sort of integration with physical sciences Although the Conference recognized that it will be difficult to include in a four year program all that is desirable, it was agreed that a realistic view of teacher education required the conference to think in terms of a four year program. In fact, area content rather than specific course hours may be a desirable approach to teacher education.

RECOMMENDATIONS:

The following were recommended as minimum requirements in the training of an effective high school biology teacher. The Conference recommended that, whenever possible, courses allowing for certification in other sciences or related fields should be taken. (Specific courses and fields must, of course, be planned in the light of certification requirements of the state involved.)* In order to provide the best possible preparation in a four-year program, the Conference recommended that the prospective high school biology teacher have:

1. A college major (i.e., a minimum of 24 semester hours) in the biological sciences, to include one year of general biology, or equivalent courses in general botany and general zoology (incorporating the subject matter areas, morphology, taxonomy, physiology and health ecology and conservation, heredity and development, evolution and paleontology), with at least one-third of the total content devoted to plant science. Course work beyond the first year should include field studies.

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* The above recommendation is essentially the same as that of the Southeastern Conference, 1954, ABT Vol. 17. No. 1.

2. Suitable subject areas which should be included are:
   a. Chemistry, with laboratory work. It was recommended that this work include organic chemistry as it applies to living things.
   b. Physics with laboratory work.
   c. Earth science, including the study of soils.
   d. Mathematics, including the study of the fundamental concepts as well as the munipulative processes, in order to enable the student to best understand the applications of mathematics.
3. A course in materials and methods of teaching high school biology is strongly recommended. Professional education courses should include experience in the following areas:
   a. The nature of the learning process.
   b. Human growth and development.
   c. Professional laboratory experiences.
   d. Interneship.
   e. Group dynamics.
   f. The secondary school program (the role of the school in society, curriculum, history and philosophy of education, and the like).
   g. Testing and evaluation.
4. Appropriate general education courses (humanities, social sciences, and communication skills) required of other high school teachers.

BACKGROUND:

Teachers cannot be prepared for everything, but the colleges can prepare them for the problems they are most likely to encounter in their first teaching positions. They can introduce the teachers to such reference material and to many methods of handling class, field, and laboratory work.

RECOMMENDATIONS:

The subject matter course work of the prospective teacher should contain as wide a spread as possible within established credit-hour limit for the major or the minor.

   a. This can be carried out more easily in schools utilizing the quarter system, but it can be facilitated under the semester plan by reducing credit hours for specific courses so that as many as possible of them may be included in the student's program.
   b. A similar result may be achieved by replanning courses offering a higher number of credit hours so that they will include appropriate units giving the desired spread. A senior integrating biology course, possibly of seminar type, for college majors or minors may well serve the function of focusing attention of the fundamental concepts of biology. In the absence of a specific integrating course, such a course as ecology, based on fundamental concepts and involving critical thinking, might fill the need to a large extent.

   As to integration with physical sciences, the Conference makes no recommendation concerning unified courses which cover both biological and physical sciences. Whether or not such courses are organized is a matter for each college. It is recognized, however, that it would be impossible to teach biology without considerable integration with the physical sciences, life processes being essentially physical and chemical in nature.

B. What is the best distribution of subject matter in satisfying the generally adopted minimal requirements for certification?

RECOMMENDATIONS:

We must move as rapidly as possible toward the time when only those with the equivalent of a major in the field teach biology. In view of the present shortage of science teachers we must also recognize that many classes will be taught by those with minors or less. The minor program must therefore be designed to teach a maximum of fundamental biology within the allotted time.

Upon this foundation the college bi-

ology courses should build a balanced knowledge in terms of:

1. The plant and animal world with field methods, laboratory methods.
2. Use of literature
3. Critical thinking.

C. How can secondary school in-service programs sponsored or assisted by colleges and college personnel be made available to high school biology teachers and students?

RECOMMENDATIONS:

The Conference recommended:

1. That biologists in colleges, universities, industry, government, and research institutes recognize that they have a major personal responsibility for working with high schools.
2. That college administrators should recognize cooperative work with high schools as a proper part of the college biologist's activity, relieving him from other assignments in accordance with the time devoted to such capacity.
3. That biology departments use open house programs, career days, science days, and similar devices to introduce junior and senior high school students and their teachers and parents to the institution's educational and research program and opportunities in biological sciences.
4. That pre-college apprenticeship programs, in which high school students have an opportunity to work intensively for periods of a week or two during the school year, or an entire summer, with active scientists in research institutes, biological stations, universities and colleges be expanded.
5. That assistance for school camping programs be given students and teachers by colleges.
6. That extension services provide a larger number of courses in the biological field at appropriate times.
7. That properly organized workshops and work conferences, which are comparable in length and quality to standard courses, carry full credit.

D. What are desirable provisions for teaching science methods courses?

RECOMMENDATIONS:

1. The instructor of a science methods course:
   a. Should have training and experience as a high school biology teacher.
   b. Should have had professional knowledge in methods and problems of teaching, and educational psychology.
   c. Should visit the students in their practice teaching.
   d. Should keep up to date in contacts with high school biology classroom activities and textbooks.
2. There should be:
   a. Complete cooperation at all points in the preparation of prospective teachers.
   b. Agreement in the objectives and purposes of the training program, both academic and professional.
   c. Dual counseling by both fields with competent counselors.
   d. An educational psychologist as a member of the team responsible for teacher education.
   e. A following program for beginning teachers by the colleges to evaluate progress and determine problems in order to lend assistance.
   f. Teacher load calculation to give time for evaluation of students.
3. Members of science departments:
   a. Should be available for counseling and encouragement.
   b. Should invite teachers back to participate in seminars and to present problems in methods courses.
4. The conference wished to reemphasize the urgency of establishing good working relationships between the subject matter specialist and the professional educator; without such relationships it is difficult to develop an effective special methods course.
5. Extra compensation should be given for extra work.

LEADERS PART II
"Melding" the recommendations of their four groups into the conference recommendations for final approval.

*IV. State Departments and/or Other Major Administrative Units*

BACKGROUND:

A cooperative state plan for improving biology teaching is needed in all states. The state department of education is an important facilitative agency. Other agencies that should be considered are institutions of higher education (public and private), professional educational organizations, scientific societies, and biologists.

A. What basic services could adequately staffed administrative units render to teachers of biology at all levels?

B. How can we improve certification?

RECOMMENDATIONS:

1. Local, intermediate (county and district) and state administrative units should plan to contribute as follows:
   a. Provide publications dealing with program evaluation, trends, promising practices, use of materials, outdoor teaching, land management, annotated bibliographies of available curriculum bulletins, directories, etc.
   b. Provide the organization, study, and leadership for cooperative curriculum development, preparation of publications, conferences, workshops, and research efforts.
   c. Provide much more consultative service. This consultative service should utilize cooperative techniques in working with schools and teachers. These services should be primarily on invitation. Consultants should be specialists primarily in program development. Specialized help to biology teachers would be through:
      1.) Helping faculties and individual teachers to improve their programs.
      2.) Helping cooperative committees, where the committees set up the problem and the consultant helps the committee to solve it.

   The help of biologists should be sought through professional educational organizations, scientific societies, field services of institutions of higher education, and state agencies such as departments of agriculture, health, and conservation.

2. Every state should have an advisory committee on certification and teacher education. Mixed study committees of college specialists, teachers, and the lay groups should be set up to review certification requirements for biology

Recorders Hall, Matala, Mulaik and Smith reading their group recommendations to the conference members for consideration. Director Weaver and four chairmen Baker, Wareham, Breukelman and Phillips record the suggestions of the members.

teachers. Research studies of the job requirements and teaching combinations should be made.

3. General administrators, department heads, and experimental teachers should all assume professional responsibility for helping teachers who need help. Such a policy should be made known to all teachers.
4. The present situation in which over half of the classes in biology taught by teachers who have had an inadequate education in biology should be remedied through the following measures:
   a. Teacher educating institutions should re-examine their teaching minor in biology and their programs of general education.
   b. Local administrators should assign teachers as efficiently as possible.
   c. State departments of education and accrediting agencies should encourage careful assignment of teachers.
   d. The total program of the beginning teacher through the fifth year should be so planned as to result in at least the equivalent of a teaching major in biology.
5. The adoption of the five year period of preparation for the certificate of the highest grade should be encouraged by biologists. In this way curriculum competition in the college will be reduced, teaching experience can be utilized in maturing the teacher, and more adequate subject matter preparation would be possible. Accommodation to supply and demand should be a responsibility of state departments of education but requirements for special certification should be held to the highest possible level.
6. Attempts should be made to have the problem of improving biology teaching considered at:
   a. The annual conference of the National Council of Chief State School Officers.
   b. The regional workshops of NCC-SSO, and
   c. The annual workshop of the Conference of State Consultants.

# Part III: Summary of Action Recommendations Of State Teams

G. ROBERT KOOPMAN
Associate Superintendent
Michigan Dept. of Public Instruction

A. *Recommendations of State Teams*

1. Teacher Education and Certification
   a. Send out a questionnaire based on the workshop report to ascertain how colleges conform to minimal requirements in biology as recommended by this conference.
   b. Improve the total pattern of teacher education in own institution.
   c. Make practice teaching more than a simple apprenticeship experience. This would involve joining with teacher educating institutions in setting up genuine internship programs.
   d. Plan a basic course in biology of an interdepartmental nature where necessary.
   e. Report to the State Committee on Teacher Education and work with them in formulating recommendations in line with the report.
   f. Ask the deans of instruction in state colleges to implement the recommendations in the report.
   g. Carry the recommendations of the workshop to the authority that certifies teachers in the state. Then work with and through that authority to study problems of institutional pattern, instructional method, and minimum requirements.
   h. Arrange for a cooperative consultation service for institutions of higher education wishing to improve their teacher education programs.
2. Improvement of the Instructional Program through Curriculum Development and In-Service Education
   a. Arrange to have a representative of each school attend the annual meeting on instruction called by the State Department of Education.
   b. Arrange a meeting of the heads of the science departments and representatives of the college of education at the state university.
   c. Arrange short local conferences on Saturdays or evenings (these might be sponsored by local colleges and universities).
   d. *Every conference participant should go home and put into practice at the local level ideas agreed upon here.*
   e. Publish an article on biology teaching in the state education journal.
   f. Call on the educational head of the state and his staff (especially curriculum coordinators) to report on the workshop, and plan follow-up activities.
   g. *Every workshopper should present the results of this conference along with implications to his own faculty.*
   h. Organize a state committee on the improvement of biology teaching. Those who attended this conference would be the nucleus of this committee.
   i. The teacher responsible for methods courses should give consultation time to high school teachers in the area served by his institution.
   j. Set up a state summer workshop in the field situation centered around problems such as curriculum, evaluation of textbooks, laboratory and field techniques, and audio-visual materials and methods.
   k. Support the state curriculum committee or committees responsible for the advancement of secondary education.
   l. Make a study of the biology curriculum needs in the state.

m. Ask industries in the state to help support conferences and workshops.
n. Arrange a state leadership conference to develop leadership and plan for regional conferences.
o. Report the findings of the workshop to state curriculum and course of study committees.
p. Wherever possible relate the teaching of biology to the programs of the State Departments of Conservation, Health, and other agencies.
q. Ask the State Department of Education to disseminate a list of available textbooks in the subject area.
r. Call a state meeting of key biology teachers for the purpose of presenting the workshop findings to them.
s. Ask the State Department of Education to call section meetings of high school and college biology teachers to discuss the report and to set up committees to study its implications.
t. Ask the State Department to make a survey of audio-visual aids, printed matter, and other materials from state sources and to publish a list of useful materials.
u. Strengthen the communication between the teachers in one school system and teachers in other school systems who are trying to improve teaching. This could be done through workshops, conferences, newsletters, etc.
v. Organize a state curriculum committee on science and mathematics, and set up a curriculum study in these areas.

3. General Administrative Measures
   a. Support the programs of the Future Teachers of America.
   b. Organize a section on science education in the State Academy of Science and Arts.
   c. Strongly support the improvement of local salary schedules throughout the state.
   d. Help plan better types of salary schedules.
   e. Advance salary scales so that biology teachers will be encouraged to work out majors in biology.
   f. Urge the Junior Academy to continue the science "talent search."
   g. Abolish state scholarship tests in the field of biology.
   h. Ask the president of the land grant college of state university to provide consultant service to biology teachers.
   i. Arrange for cooperation between the scientists of the state and the professional organizations of teachers.
   j. Arrange a consultant service to be available in an area around each of the state colleges and their neighboring private institutions.

4. Publicity and Information Services
   a. Communicate through the state educational journal.
   b. Communicate through the state publication of the Congress of Parents and Teachers.
   c. Carry news of the conference to the science consultants in school systems.
   d. Arrange for publicizing the workshop through regional meetings of the state teachers association.
   e. Get information about the workshop results to beginning teachers through heads of biology departments.
   f. Have the NABT send copies of the final report to key people in the state, especially members of the State Department of Education and college and university personnel engaged in preparing teachers of biology, and superintendents of schools.
   g. Reports on the workshop before voluntary groups such as Chicago Biology Round-Table, Catholic Science Teachers Association, and State Academies of Science.
   h. Circulate the entire conference report to high school and college teachers of biology.
   i. Supply the newspapers with an adequate publicity release.
   j. Arrange a report of the workshop through the State Conservation Department house organ.

k. Ask the universities in the state to distribute summaries of the workshop findings.

B. *Comments on the Recommendations*

The bringing together of such a fine group of biology teachers and others interested in improving the teaching of biology is in itself a major event. The sincere and intelligent participation of all was very impressing. As an administrator interested in program improvement the author welcomes any sincere attempt of any group to improve teaching no matter how critical that group may be. Everyone, including administrators, must recognize the need for good programs in all scientific fields.

The second comment deals with a matter often alluded to in the conference, but not crystallized—the need for really professionalizing teaching. We are facing a great shortage of all teachers. This shortage calls for a policy decision—either we must upgrade the profession or degrade it. We must ask for high salaries and a share of the best of American youth to serve the profession or we must settle for low salaries, teacher helpers and the lower portion of the barrel. The choice we make will be fundamental not only to the profession of teaching but also to our culture.

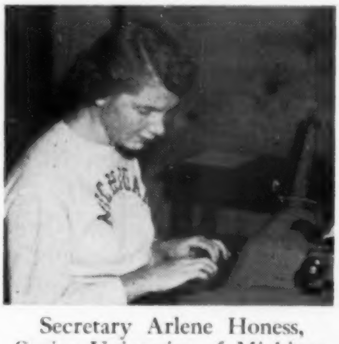
Another comment refers to the confusion expressed concerning ways of improving teaching in this field. Better progress will be made if here and now we recognize the problem as centrally a problem in curriculum development—a problem to be solved through improving the program of the American high school and the teachers who handle it.

Possibly a comment on the field services of institutions of higher education may help. This year as colleges face increased enrollments the question of the further increase in field services will be questioned. The tendency to increase the services is still with us. If we want teaching interneships and more consultative services then, it seems, that we should say so. We should spell out the services needed to improve the teaching of biology in each state. My guess is that most administrators will welcome demands in this field.

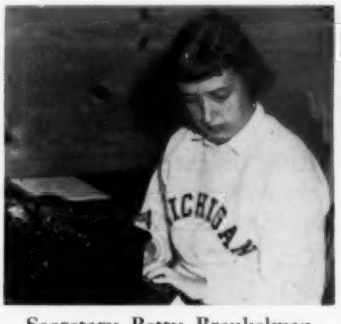
While pressure should be placed at the crucial points, separate approaches to the problem of program improvement by subject matter groups operating unilaterally must be questioned. Such drives for status usually result in some good and some dislocations. They often result in bad starts. Biologists should be able to accept the grand strategy of working with others toward a common, humanistic, general education. Maybe they should join forces with mathematics and the other sciences, both physical and natural. Or better yet, they should join with all other forces wanting to improve the culture and functioning of the American community school. No science instruction nor, indeed, any other kind will thrive in a school culture oriented to superficial instruction and comic books. Actually the American people are proceeding ponderously but—in time units of social change—swiftly toward the creation of a folk school that will through serving *all* American youth maintain and enhance the culture. Scientific behavior is an essential ingredient of that culture. Without it we can do no better than to decay.

THE SECRETARIES OF THE CONFERENCE.

Secretary Mary Kane,
Senior University of Michigan



Secretary Arlene Honess,
Senior University of Michigan



Secretary Betty Breukelman,
Senior, Kansas State Teachers College

# The National Science Foundation Program

KEITH KELSON
The National Science Foundation

Whether we like it or not, it is an unassailable fact that science and technology have become the hallmark of our era. Even more to the point—they have become the very foundation of our own particular national way of life. Science is no longer a tranquil ivied-tower pursuit removed from the ken of everyday life, its impact, both realized and potential, on society is a matter of utmost importance. Particularly is this so in these days of international semi-hostility.

Recognizing these things, the Congress created the National Science Foundation in 1950 and authorized and directed it "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." This, then, is our mandate. The creating Act also identifies certain specific things which we in the Foundation may do and, within broad limits, specifies certain parameters which we should not exceed. We are authorized to support basic scientific research, to foster the international exchange of scientific information, to award fellowships and scholarships in science, and to assess the role of science in national affairs. We are further directed to play a role among the various agencies in stimluating both public and private, in matters of science and science education. Some of the broader and more challenging activities of the Foundation have been centered in our Division of Scientific Personnel and Education. I am a member of that Division. Let me say, however, that I use the word "centered" deliberately because through the entire Foundation staff there runs a current of keen interest in science education matters.

One such program is the Scientific Manpower program whose function is to find out in general what kinds of scientists there are, who they are, where they are, what they can do, and how many of what kinds are needed under given conditions. A second program is the Fellowship Program. The staff of the fellowship group try to see as a whole the fellowship-scholarship movement and to advise appropriate action programs to meet the more difficult problems that are beyond the scope of other groups. Awards are made, according to statutory requirement, "solely on the basis of ability" and are given in such a way as to achieve an equitable distribution according to field and level of study and geographic distribution of permanent residences of Fellows. Last March we offered 715 predoctoral and 70 postdoctoral awards. Fellows may study at any accredited non-profit institution of higher learning in this country or approved institutions abroad.

A third group in our division is called the Education in the Sciences Program. Because I suspect the activities of this group are of great interest to most of you, I shall attempt to describe them to you somewhat more fully than those of the other programs. You will note the breadth of interests implied by the program name—Education in the Sciences.

Studies have shown that of the top quarter of graduating high school seniors only about half continue into higher education. While by no means all of the half who do not continue fail eventually to achieve their capacities, it is a lamentable fact that many do. Beyond a doubt both the individuals and society would gain if more of these people were to continue their education for a longer period. Why they do not continue is thus a matter of prime importance. The traditional answer to this problem has been money. Yet we now feel certain, that although money is important, there are other factors meriting serious attention. One of these is motivation. And this is not unrelated to financial resources. What one potential college student may regard as

insufficient money to warrant beginning a college career may be more than adequate for another. Why? Clearly the strength of an individual's desire—his motivation—for a college education is a controlling factor. It has been stated repeatedly of late that today almost any really able student who really wants a college education can obtain one somewhere in our country. Be that as it may, the motivation factor is important when we base the eventual success—perhaps even the survival—of our way of life on the skills and education of the people. Putting it bluntly, the strength of a democracy is more or less proportional to the intelligence and education of its adherents. This being so, unrealized intellectual resources in all fields of human activity are properly a matter of major concern to all of us.

But whence arises a strong motivation for higher education? All of us know that this is one of the most complex of human problems. We also know, however (and this has been documented objectively), that many successful people received their first strong motivations while in high school. True, pre-high school or outside interests often had prepared the soil for proper growth of the seed. But it was the *teacher* who planted that seed. Often a great number of productive careers have been traced to but one teacher—a teacher adept, stimulating and provocative. If you will accept my personal belief—no, stronger than that, my conviction—that the teacher quite literally supports our civilization, then you may accept my conviction that the teacher is a key point of entry into the problems of increasing the realization of the intellectual potential of the nation's youth. Perhaps you will forgive me if I appear a bit trite and evangelical when I plead a further personal conviction that aside from the cloth there can be no higher, more praise-worthy activity than that of the teacher.

It is appropriate at this point to examine in a simple fashion the teaching process. Gilbert Highet once wrote to the effect that teaching is an individual art created, discovered, or developed anew by each teacher. I think most of us will agree that superior teaching skill stands on a tripod of characteristics—the inborn qualities of the teacher, his basic pedagogical training, and his subject matter knowledge. Now what does this abstraction mean to us in the concrete? First, practically, we can do little about the inborn personal qualities other than to try to identify and recruit those having them. This is itself such an obviously worthy pursuit that I shall only mention it here. Second, schools and departments of education now offer to both teachers-to-be and in-service teachers a wide range of courses in professional pedagogical subjects. Most schools have attempted to gear their on-going programs in education to very practical approaches. Generally, in-service teachers find available both advanced courses in professional education and refresher courses in new methodology. These courses are usually tailored to the level appropriate and useful to the teacher. It is, of course, obvious that the training of teachers is the main business of a School of Education. I do not propose, however, to embroil myself here in a debate on what is the most desirable amount of pedagogical training that a teacher ought to have. Third, is the item of subject-matter knowledge. One of the most obstinate problems in the entire science education process is the time lag in the dissemination of new knowledge and understandings from the research laboratory to the classroom. Truly in this respect the science teacher faces formidable odds. Whole new chapters are being written daily in science's technical reports. And because the high school science classroom is normally the point where definitive science may first be taught, yet most remote from the research laboratory the time lag is often most apparent there. I have been told, for example, by some mathematicians who are personally familiar with the circumstances that most high school mathematics is at least 30 years out of date. Maybe so. I am not competent to pass judgment on that point. I am a biologist, however, and I do feel that much high school—and college—biology is somewhat antiquated. If you will recall now the significant role of the high school teacher in not only giving many persons their only training in science but in providing both a solid foundation and instilling a strong motivation in those who may continue to higher academic levels, you will realize immediately the singular importance of the high school teacher—subject matter problem. May I add that I do not for the moment suggest that the science teacher must

know *all* about the new frontiers of his or her own field—the achievement of such a condition is patently an absurdity—I do submit that a science teacher, in order to be the stimulating, informative mentor we need, must be given access to the appropriate kind and amount of subject-matter knowledge.

Let me expand on this a bit more. It is not difficult to identify several important reasons why some high school teachers do not reach their full potential. First, many persons now teaching science were poorly trained when they began their careers as teachers. It has been an all-too-common practice for college and university science departments to leave to the departments of professional education the responsibility for training potential teachers. Second, even many of those who were relatively well-trained as of the time they began teaching have lost touch with modern advances in science. Financial limitations usually have precluded the possibility of effective refresher training. In an era when scientific advancement is a matter of great interest to young people, stimulating and challenging instruction demands that the teacher have some knowledge of recent developments.

Third, many teachers ill-prepared to teach certain subjects are, by force of circumstances, required to teach those subjects. Approximately half of the high schools in the United States have faculties of seven or fewer persons. Especially in these smaller schools, one teacher may be expected to teach a number of different courses, some of them only slightly related to the teacher's earlier training. Science teachers are keenly aware of this situation and often express the need for increasing their knowledge of the sciences which they are required to teach but in which they do not regard themselves as fully competent.

Although present standards of science instruction are not as high as they could be, there is overwhelming evidence that the situation will materially worsen unless definite and effective steps are taken to reverse present trends. The growing shortage of teachers, competent or otherwise, is becoming acute for three reasons:

A. The number of persons preparing to teach, especially in science subjects, is decreasing;
B. There is an increasing loss of teachers to occupations offering greater financial return and opportunities for growth; and
C. The number of high school students is increasing rapidly owing to high birth rates in the period 1941 to present.

Present production of teachers is less than enough to meet present attrition loss, much less than enough to effect an increase in effective numbers. Thus, considerable pressure will be felt to lower still further the already modest standards of instruction. If we are to produce better trained students and more of them, it seems imperative that *immediate* attention be devoted to (1) increasing the competence of present and future teachers, (2) inducing more persons to remain in teaching positions and (3) recruiting more new teachers and re-recruiting experienced teachers who have left the profession.

The difficulty we now face in recruiting and retaining adequate numbers of competent teachers may be largely attributable to financial considerations. Low pay scales are not only important directly, but serve to prevent teachers from engaging in activities which will improve their professional competence. They are also an important deterrent to potential teachers and make the in-service teacher receptive to offers of other kinds of employment. In view of the demands of industry for technically trained persons, science teachers especially are subject to more lucrative offers. For the present at least, it would seem outside the bounds of feasibility for the National Science Foundation to effect directly an over-all increase in teacher pay scales.

It is possible, however, for the National Science Foundation to establish several kinds of programs whereby an in-service teacher of science or mathematics would be provided funds to pursue a course of study in science designed to improve his competence as a high school teacher. Further, similar awards extended to former teachers who indicate a desire to return to the profession would enable many of them to do so at an effective level of competence. It is possible that this factor alone—constituting in effect a kind of "fringe benefit" for the entire profession—would have at least a modest impact on reducing science-teacher attrition and in increasing the motivation of able young persons toward careers in science teaching. An appropriately designed

program would also serve to focus public attention on the teacher problem. There may thus ensue an increase in teacher prestige and a small additional step would be made toward achievement of that degree of public awareness that must necessarily precede an improved economic status for the teacher.

Assuming that it is desirable to try to effect an increase in the scientific knowledge of high school teachers, it is then pertinent to inquire whether suitable programs are now in existence which might provide teachers with the requisite training. Many teachers presumably would not be seeking advanced degrees in science fields nor could they, in most cases, be considered as having training equivalent to that of the usual science department graduate student. And, since their programs of study should be directed primarily toward science rather than toward additional intensive study in professional educational subjects, they probably should not be classified as graduate students in education. Nor would they be equivalent, in principle or in fact, to undergraduate students. Thus their position would be an anomalous one. There is a need, therefore, for special kinds of subject matter courses designed—or adapted—to meet the needs of these teachers. There are relatively few institutions in which this kind of program exists. There are a number, however, in which the need here outlined is being felt and in which some sort of action program is being sponsored or planned.

And now, how has the National Science Foundation implemented this rationale?

One important way is to cooperate with various colleges and universities in developing special subject-matter programs offering special training in various sciences or likely combinations of sciences. These are summer programs and vary in length from four to eight weeks. The teaching staffs are carefully chosen for their knowledge of science and their ability to convey that knowledge in a way meaningful to and usable by the teachers who come to learn. Some of these Summer Institutes, as we call them, are for high school teachers, some for college teachers and some are, to a degree, inter-locked combinations. Each is in its own way uniquely designed. We have been able to support a number of these and their success has warranted a growth of this program. This summer we are supporting about a dozen; next summer we hope to be able to support about 20.

We are also supporting an experimental program of visiting lecturers to see if this will be an effective approach.

We are encouraging schools in every way appropriate to a Federal agency to look at their own on-going programs of training teachers-to-be and in-service teachers with a view to devising more effective methods. We have reason to believe that as more and more institutions gain experience with summer institutes, they are incorporating that experience into their regular efforts.

We also concern ourselves about curricula and resource materials and have supported pilot efforts in these directions.

We also spend an appreciable amount of program money in supporting fact-finding studies upon which we may be able to measure the effectiveness of present programs and structure future ones. We are presently studying, for example, the feasibility of establishing some year-long institutes. Like our present summer institutes these may have provision for offering financial assistance to participants.

In conclusion let me say that the Foundation does not—indeed, can not—operate in a vacuum. We consider our role to be essentially that of supporting the scientific and academic communities. To play this role successfully we constantly solicit the advice of those communities. We listen constantly for single dissenting voices as well as for majority opinions; we are not so naive as to think that all the good ideas arise within our own walls. If we are to be able to help you effectively, you must be willing to tell us where help is most needed. This is one of the reasons we could support this conference. We shall pay serious heed, I assure you, to your deliberations.

It is especially gratifying to be able to support an assemblage of this sort where high school and college teachers, educational administrators and subject matter specialists meet on common ground to consider what we must agree is a matter of mutual concern. Such cooperative enterprises augur well for the future.

## Participants in The North Central Conference on Biology Teaching
## University of Michigan Biological Station, August 19-30, 1955

*First Row* (l. to r.): Phillips, Karling, Stewart, Armacost, Fuller, Lawson, Klinge, Abbe, Townsend, Larson, Hall, Vaughn, Brown, Hanes, Linsheid, Keene, Brother Charles, Higbee, Sister Aelred, Kugel.

*Second Row:* Stockard, Beuschlein, Conyers, Johnson, Jeffers, Howell, Bryner, Schreiber, S. Mulaik, D. Mulaik, Dale, S. Pattee, H. Pattee, McNelly, M. Hewitt, S. Hewitt, Miller, L. Bond, Sister Hilaire, Matala, Wolfson.

*Third Row:* Weaver, Swenson, Stork, VanDeventer, C. Brown, Haslett, Spangler, Pettit, H. Bond, Bullington, Weimer, Bowman, Dana, Webster, Kenyon, Father Pax, J. Breukelman, Osborne, Ballard, E. Stirling, T. Stirling.

*Fourth Row:* McCuskey, Behnke, Hanion, Novak, Wareham, Perrin, Father Rice, Yambert, McKibben, Clausen, Rasmussen, Mouser, Anderson, Olson, Rudolph, Baker, Paulson, Scribner, Smith, R. Breukelman, Esten, O. Ballard.

# NORTH CENTRAL CONFERENCE ON BIOLOGY TEACHING

## University of Michigan Biological Station

## August 19-30, 1955

## Participants

### STAFF

1. *Richard R. Armacost,* Associate Professor of Biological Education, School of Science, Education and Humanities, Purdue University, W. Lafayette, Indiana.
2. *John Breukelman,* Chairman of Steering Committee, Head of Department of Biology, State Teachers College, Emporia, Kansas.
3. *Paul Klinge,* Biology Teacher, Thomas Carr Howe High School, Indianapolis, Indiana.
4. *Alfred H. Stockard,* University of Michigan Biological Station Director, Ann Arbor, Michigan.
5. *Richard L. Weaver,* Director, Associate Professor of Conservation and Education, School of National Resources, University of Michigan, P. O. Box 2073, Ann Arbor, Michigan.

### STEERING COMMITTEE

6. *Arthur Baker,* Past President NABT, Instructor of Biology, Community High School, Crystal Lake, Illinois.
7. *Muriel Beuschlein,* Secretary of Steering Committee, Counselor for Student Teaching, Chicago Teachers College, 6800 Stewart Ave., Chicago, Illinois.
8. *George W. Jeffers,* Professor of Biology, Longwood College, Farmville, Virginia.
9. *Irving C. Keene,* Biology Instructor, Brookline High School, Brookline, Massachusetts.
10. *Howard M. Phillips,* Dean of Graduate School, Emory University, Emory University, Georgia.
11. *Brother Charles Severin,* President NABT, St. Mary's College, Winona, Minnesota.
12. *Harvey Stork,* (Professor of Botany, Carleton, College, Northfield, Minnesota.) c/o Spruce Tree Lodge, Mesa Verde, Colo.
13. *Paul V. Webster,* Biology Teacher, Secretary-Treasurer NABT, Bryan City Schools, Bryan, Ohio.

### NON-REGIONAL

14. *John Behnke,* AAAS, 1515 Massachusetts Avenue, N.W., Washington, D. C.
15. *Frances Hall,* Local Chairman AAAS Meeting, (Bass High School, Atlanta, Georgia.) Teacher's College, Columbia Univ., N. Y. City.
16. *Edna Higbee,* Principal and Head of Biology Department. University School, Pittsburgh, Pennsylvania, First Vice-President NABT.

(8) *George Jeffers,* Professor of Biology, Longwood College, Farmville, Virginia.

17. *Keith Kelson,* National Science Foundation, 1501 "H" Street, Washington, D. C.
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19. *Stanley B. Mulaik,* Assistant Professor of Biology, University of Utah, Salt Lake City, Utah.
20. *Richard E. Paulson,* Executive Secretary, Committee on Educational Policies, Division of Biology and Agriculture, National Research Council, Washington, D. C.
21. *Ileen E. Stewart,* Editor, AIBS Bulletin, American Institute of Biological Sciences, 2000 P Street, N.W., Washington 6, D. C.
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23. *Dorothea Mulaik,* Biology Division, University of Utah, Salt Lake City, Utah.

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(7) *Muriel Beuschlein,* Secretary of Steering Committee, Chicago Teachers College, Chicago, Illinois.

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25. *Robert A. Bullington,* Professor of Biological Sciences, Northern Illinois State Teachers College, DeKalb, Illinois.
26. *Harry J. Fuller,* Professor of Botany, University of Illinois, Urbana, Illinois.
27. *Father Walter Pax,* Chairman, Department of Education, DePaul University, Chicago, Illinois.
28. *Sister Mary Hilaire Ryan OP,* Professor of Biology, Rosary College, River Forest, Illinois.
29. *Robert L. Smith,* Chairman of Biology Department, DeKalb High School, DeKalb, Illinois.
30. *Albert Wolfson,* Associate Professor of Biological Sciences, Northwestern University, Evanston, Illinois.

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(1) *Richard R. Armacost,* Associate Professor of Biological Education, Purdue University, W. Lafayette, Indiana.

31. *Mrs. Catherine W. Dale,* Biology Teacher, Highland Public School, Highland, Indiana.
32. *Virginia Esten,* (Delphi High School, Delphi, Indiana.) Graduate School, University of Michigan, Ann Arbor, Michigan.
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(3) *Paul Klinge,* Howe High School, Indianapolis, Indiana.

35. *Donald E. Miller,* Professor of Science, Ball State Teachers College, Muncie, Indiana.
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37. *Thomas Stirling,* Vice-Principal, Thomas Carr Howe High School, Indianapolis, Indiana.

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39. *Sherman Hoslett,* Head of Biology, Luther College, Decorah, Iowa.
40. *Dorothy Matala,* Associate Professor of Biology, Iowa State Teachers College, Cedar Falls, Iowa.
41. *Steven Pattee,* Biology Teacher, Roosevelt High School, Cedar Rapids, Iowa.
42. *Rev. Carl S. Rice,* Asst. Prof. of Biology, St. Ambrose College, Davenport, Iowa.

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(2) *John Breukelman,* Chairman of Steering Committee, Head of Department of Biology, State Teachers College, Emporia, Kansas.

43. *Ruth Breukelman,* State Teachers College, Emporia, Kansas.
44. *Dorothy Vaughn,* Biology Teacher, Neodesha High School, Kansas.

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47. *Bernard Clausen,* University of Michigan Graduate School, Ann Arbor, Michigan.
48. *H. O. Goodman,* Assistant Professor, Department of Zoology, Michigan State University, East Lansing, Michigan.
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53. *G. W. Mouser,* Associate Professor, Department of Land and Water Conservation, Michigan State University, E. Lansing, Michigan.
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61. *Sister M. Aelred,* OSF, Biology Instructor, College of St. Teresa, Winona, Minnesota.
62. *Robert Hanlon,* Biology Teacher, Mankato High School, Mankato, Minnesota.
63. *Walter Kenyon,* Head of Biology Department, Hamline University, St. Paul, Minnesota.
64. *W. R. McKibben,* Biology Instructor, High School, Rochester, Minnesota.
65. *Sam Perrin,* Biology Instructor, North High School, Minneapolis 14, Minnesota.

(11) *Brother Charles Severin,* President NABT, St. Mary's College, Winona, Minnesota.

(12) *Harvey Stork,* Professor of Botany, Carleton College, Northfield, Minnesota.

Larsen, Wareham, Stock and Phillips are in the vanguard of the chow-line.

66. *Joseph Novak*, School of Education Graduate Student, University of Minnesota, St. Paul, Minn.

*Missouri*

67. *Mrs. O. T. Ballard*, 443 W. 62nd St., Kansas City, Missouri.
68. *O. T. Ballard*, Kansas City Junior College, Kansas City, Missouri.
69. *Lora Bond*, Professor of Biology, Drury College, Springfield, Missouri.
70. *Rex Conyers*, Biology Teacher, Senior High School, University City, Missouri.
71. *Samuel P. Hewitt*, Professor of Botany, Central Missouri State College, Warrensburg, Missouri.
72. *Mrs. Samuel P. Hewitt*, 810 S. Maguire St., Warrensburg, Missouri.

*Ohio*

73. *Glen Hanes*, Superintendent, Knox County Schools, Mt. Vernon, Ohio.
74. *Alfred Linshied*, Head Department, Shaker Heights High School, Shaker Heights 20, Ohio.
75. *Dorothy McCuskey*, Curriculum Coordinator, Bowling Green, Ohio.
76. *W. C. McNelly*, Professor of Physiology, Miami University, Oxford, Ohio.
77. *Lincoln Pettit*, Professor of Biology, Hiram College, Box 217, Hiram, Ohio.
78. *Bruce Rudolph*, Biology Teacher, Washington Township School, Wood County, Toutogaug, Ohio.

(13) *Paul V. Webster*, Biology Teacher, Secretary-Treasurer, NABT, Bryan City Schools, Bryan, Ohio.

*West Virginia*

79. *Harley D. Bond*, Professor of Biology, Salem College, Salem, West Virginia.
80. *Charles Bryner*, Department of Biology, West Virginia University, Morgantown, West Virginia.
81. *Bernal Weimer*, Dean, Bethany College, Bethany, West Virginia.

*Wisconsin*

82. *Orlin Anderson*, State College, LaCrosse, Wisconsin.
83. *Chester Olson*, Biology Teacher, Wisconsin High School, Madison, Wisconsin.
84. *E. H. Schrieber*, Dean of Instruction, Wisconsin State College, Superior, Wisconsin.
85. *Charles W. Scribner*, Chairman, Biology Department, Appleton Senior High School, Appleton, Wisconsin.
86. *Chester Spangler*, Wisconsin Department of Public Instruction, Madison, Wisconsin.
87. *Roy Swenson*, Conservation Coordinator, Milwaukee Public Schools, Milwaukee, Wisconsin.

SECRETARIES

88. *Betty Breukelman*, State Teachers College, Emporia, Kansas.
89. *Arlene Honess*, University of Michigan, Ann Arbor, Michigan.
90. *Mary Kane*, University of Michigan, Ann Arbor, Michigan.

## Bio-Buy-Lines